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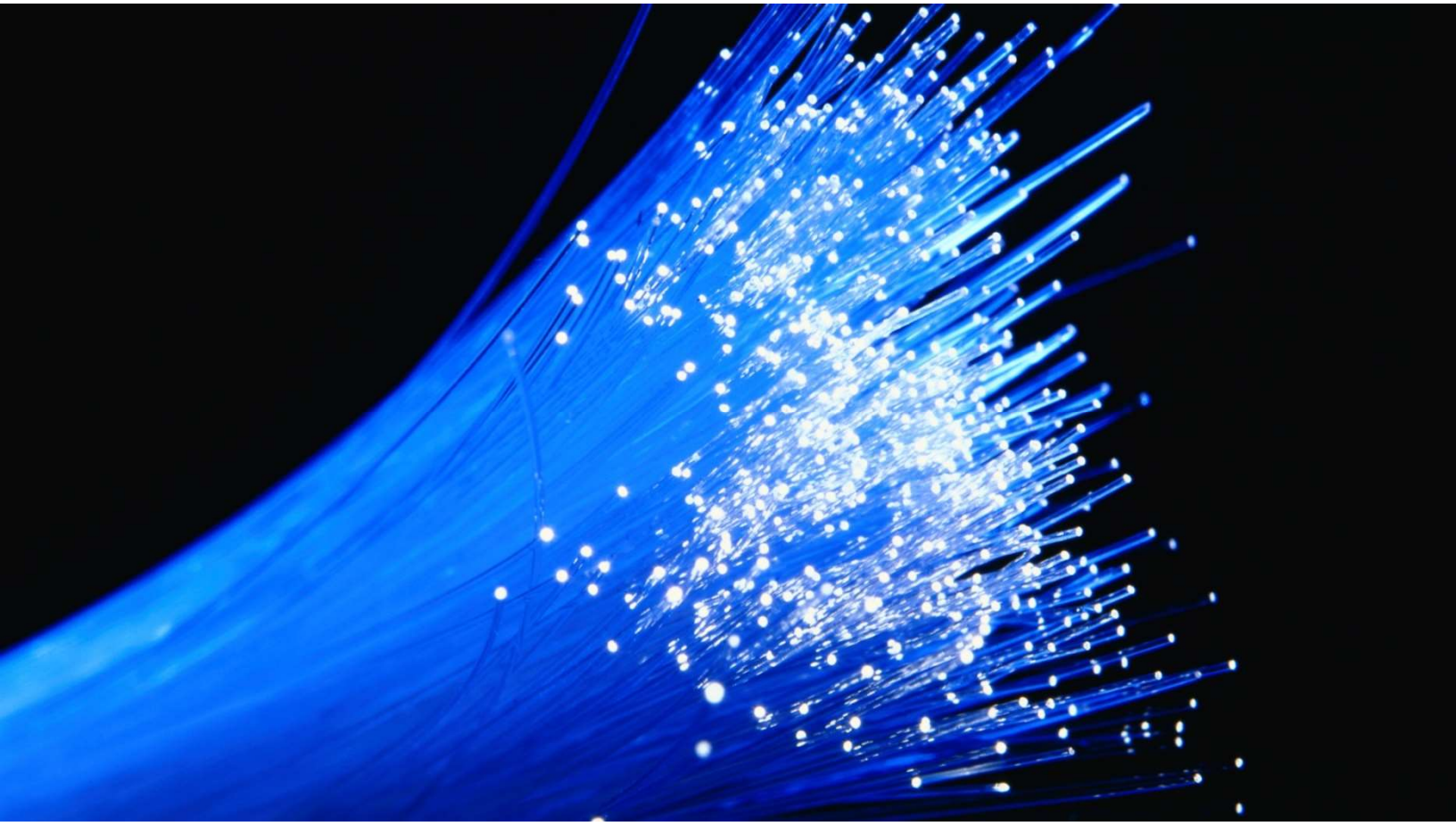

Rural Broadband Study

Prepared for Frederick County, Maryland
September 2020

Columbia Telecommunications Corporation

10613 Concord Street • Kensington, MD 20895 • Tel: 301-933-1488 • Fax: 301-933-3340 • www.ctcnet.us

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1 Executive Summary

1.1 Project Objectives

Frederick County is aware that lack of access to high-speed, affordable broadband services is an important issue for many residents in the more rural areas of the County. The County hired CTC Technology & Energy (CTC) in 2019 to perform a rural broadband study to assess the needs for broadband in the County and identify potential strategies to address these needs. CTC performed the following tasks at the County's direction:

- Identified, at a high level, unserved areas of the County, based on data and maps provided by the County, other public data sets, and desk surveys
- Met with key public and private stakeholders to identify broadband needs
- Met with representatives of internet service providers (ISP) operating in the County (or with potential interest to operate in the County to learn what market forces or County support might lead them to invest in the County
- Prepared a high-level design and cost estimate for a fiber optic network deployment to fill specific broadband gaps in the County
- Prepared a high-level design and cost estimate for a fixed wireless network deployment that might help fill additional broadband gaps in the County
- Analyzed a range of federal and state funding opportunities to identify potential sources of grants or loans (to the County or to ISPs) that might support the expansion of broadband services in unserved areas
- Developed a series of potential strategies the County could pursue to leverage federal and state funding to support the expansion of broadband service in currently unserved areas.

1.2 Project Findings

Most residents of Frederick County have access to a mix of internet services, but many locations do not have robust broadband[1] services. Comcast delivers service in most, but not all areas of

[1] Defined by the Federal Communications Commission as an internet service delivering speeds of 25 Mbps download/3 Mbps upload. ("2018 Broadband Deployment Report," FCC, Feb. 2, 2018, https://www.fcc.gov/reports-research/reports/broadband-progress-reports/2018-broadband-deployment-report.) This is also the definition adopted by the state of Maryland.

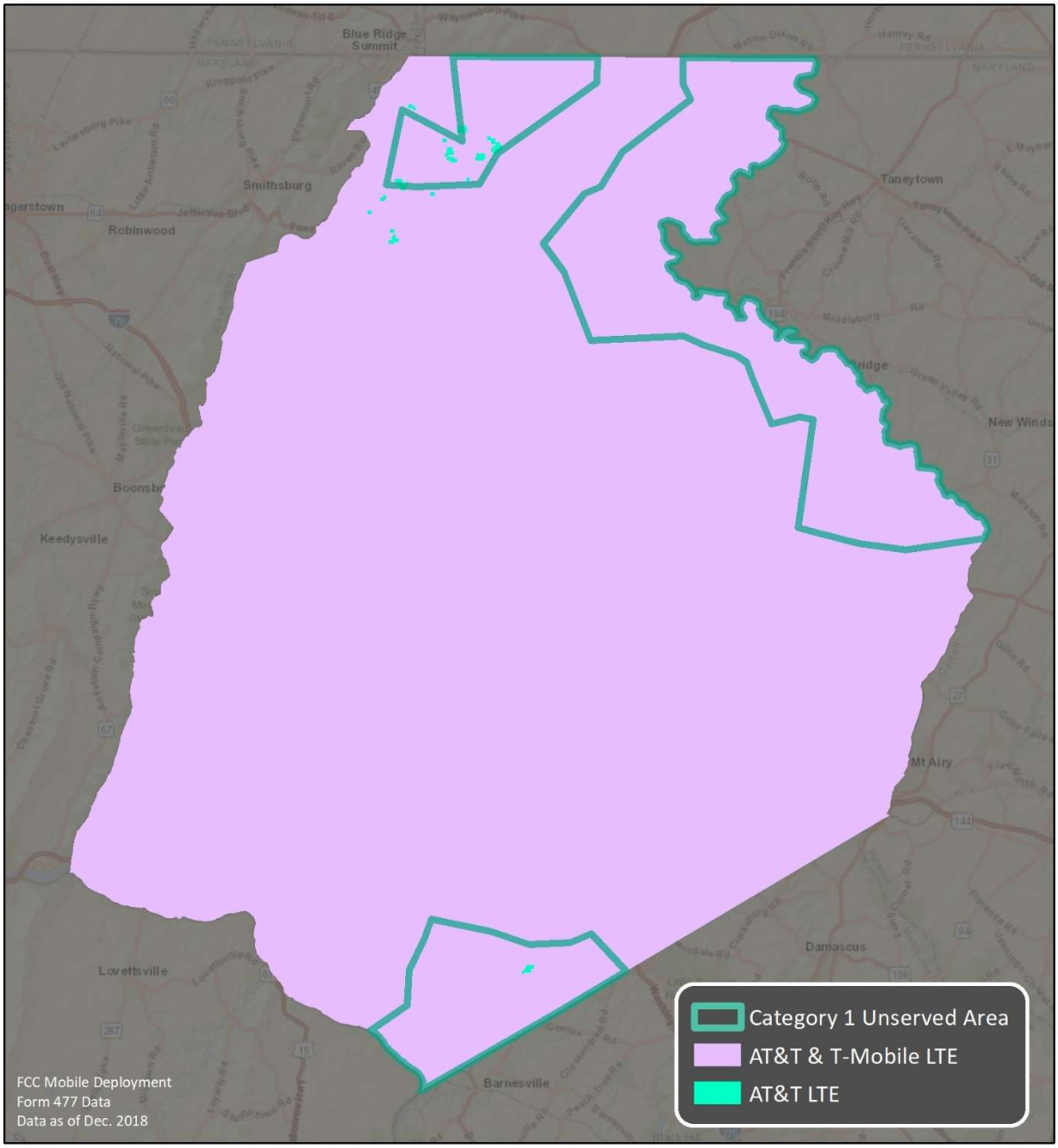
the County. While we were not able to get subscriber numbers from the fixed wireless operators, we estimate the subscribership to be in the low hundreds.

This report analyzes fixed broadband, following both federal and state definitions. Evidence from other jurisdictions similar to Frederick County, including other Maryland counties, suggests that fixed wireless solutions—especially in the unlicensed spectrum—struggle to reach broadband speeds, especially where line of sight is obscured by sloping hills or foliage.

While not a sustainable solution to the County's broadband needs, we note that mobile internet is a last resort for some households that do not have access to fixed broadband. Frederick County Public Schools, for example, has a program to distribute T-Mobile hotspots to students who cannot get broadband at home, and mobile operators are experimenting with delivering fixed wireless solution using their LTE (and later 5G) spectrum.[2] But these solutions rely on the availability of nearby fiber backhaul and towers—and are constrained by shared capacity, which results in unreliable and sub-broadband-speed performance. And they have data caps that severely limit their usefulness for today's applications, let alone tomorrow's.

[2] AT&T has delivers fixed wireless in select rural markets at 10 Mbps. T-Mobile has pilots in several markets with broadband speed capable 5G in the 600 MHz spectrum, but these are primarily in urban markets.

Figure 1: Claimed LTE Coverage



Because of the challenging economics of broadband deployment in rural areas, private ISPs likely will not invest in broadband infrastructure in currently unserved parts of the County absent some sort of financial support. State and federal funding programs may present the County and its potential partners with opportunities to fill some broadband gaps.

1.2.1 Unserved Areas

Unserved areas often include those where no infrastructure capable of delivering services that meet the federal and state definitions of broadband "passes" homes and businesses—meaning there is no infrastructure (such as optical fiber or coaxial cable) running along the road where the property can be accessed.[3] Determining whether an area is served by wireline infrastructure can therefore typically be accomplished through visual inspection—either through a review of available route photography (i.e., a desk survey) or a field survey.

Determining whether locations are considered served or unserved from a fixed wireless perspective requires a different methodology. Whether an address can "actually" be served wirelessly, with service fitting the definition of broadband, can be derived from propagation analysis. Such analysis takes into consideration geography and lines of sight, the type of base station and termination technology, wireless spectrum utilized, distance of an address from a tower, the height of the tower, placement and orientation of the antennas, number of subscribers, backhaul capacity, and other considerations. As a result, visual inspection is not sufficient to establish whether a premises can be served by fixed wireless technology. Ideally, a wireless provider would submit such information so models can be built to establish the likelihood of delivering service at broadband speeds to individual addresses.

Regardless of whether a service is wireline or wireless, the Federal Communications Commission (FCC) also determines that an area can be considered served if addresses can receive service at broadband speed without extraordinary commitment of resources and within a typical service period. If delivering service would require building a tower at the customer premises or replacing a base station at a tower, that address would not be considered served.

In the absence of rigorous field and premises testing of actual wireless network speeds, which were outside of the scope of this engagement, practical determination of wireless broadband availability will therefore have to rely on feedback from citizens who have asked for service in areas that a wireless provider reports as being served—and who have been denied service because of lack of line of sight, or who receive service at far below broadband speeds.

Considering the above definition and considerations—and based on County-collected data on unserved addresses, as well as feedback from subscribers and potential subscribers—we do not find the claims of fixed wireless providers to be credible in terms of areas where they purport to deliver 25/3 service.

[3] A "passing" is the infrastructure that literally "passes" a home or business along the road but it does not include the "service drop"—the portion of the network that connects from the road to the home or business itself. The availability of a passing to a home or business is the universally understood definition of what is served.

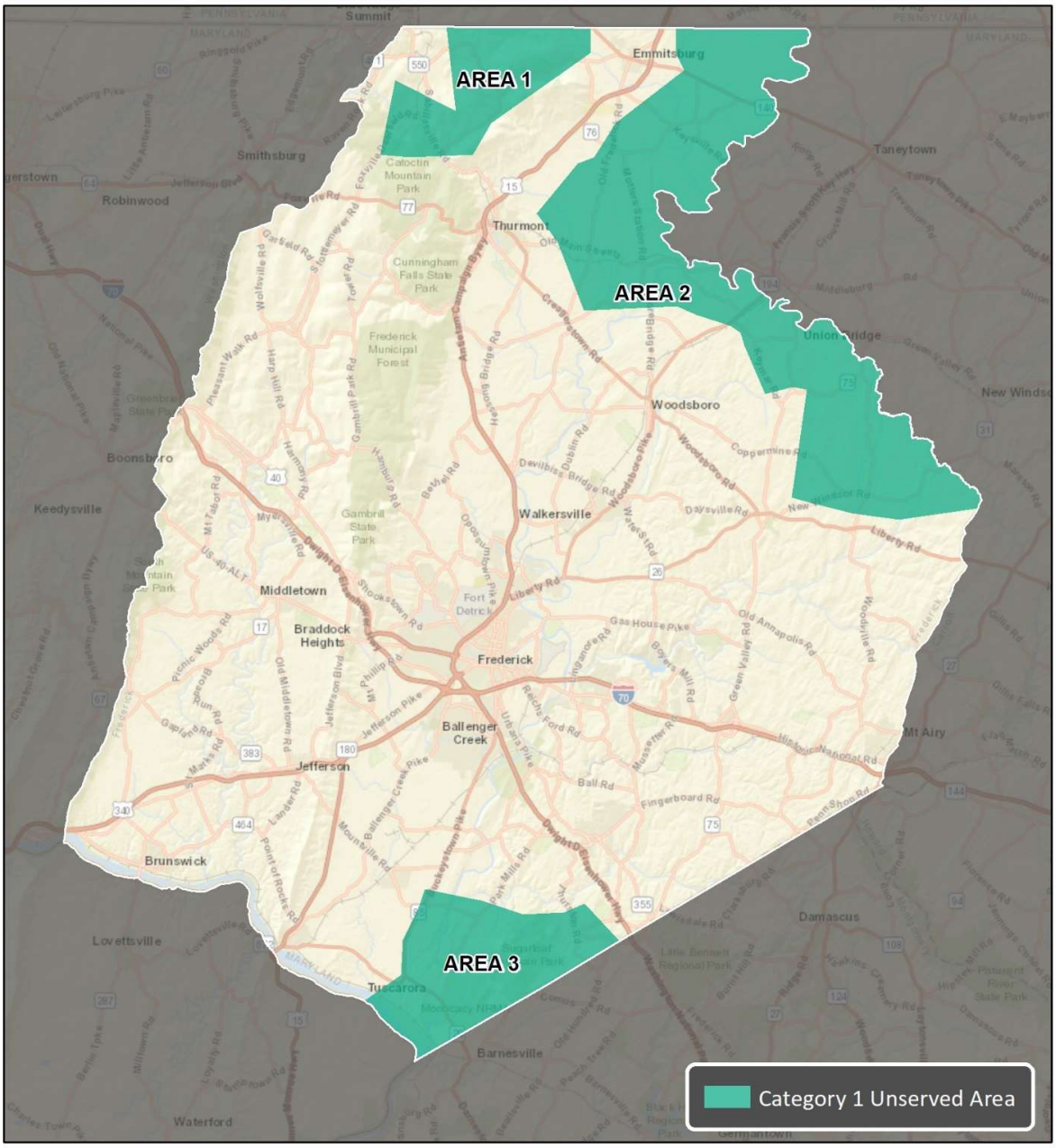
For example, Freedom Broadband claims to cover a small area in the east of the County, north of Mount Airy, with better than 25/3 service. But fixed wireless in general struggles to maintain broadband speeds, especially in the unlicensed spectrum. And this service area is also characterized by forested lands which further impedes signal strength.

While Freedom claims a modest area, likely from towers in Carroll County where they have a larger presence, Telegia claims coverage of almost the entire County with better than 25/3 service. This is highly improbable as it would require a very large number of towers to provide coverage, and even in the best case scenario, there would be areas that simply could not get a clean line of sight.

In general, the FCC is skeptical of fixed wireless claims and mostly discounted such providers in its recent map showing areas eligible for funding based on there being no broadband service in any part of a census block (see Section 1.3.2.1 below). The FCC did not recognize either Freedom or Telegia as providing broadband speeds that would make the County's rural areas ineligible for funding. ***The findings below about the County's unserved areas therefore focus on premises that are unserved by wireline infrastructure; we discuss the wireless technology and claims in more detail elsewhere in the report.***

Based on our review of a range of data sets and our own high-level surveys, we estimate the County has approximately 3,000 unserved premises (referred to herein as "Category 1")(Figure 2).

Figure 2: Category 1 Unserved Areas



A second category of unserved locations ("Category 2") comprises pockets of unserved premises located on isolated, low-density roads that fall within areas that are otherwise served. In other words, while the larger areas around these homes are generally served, these locations are on roads that do not have broadband infrastructure, usually because the density of homes is so low that the incumbent provider is not obligated to pass those locations with their infrastructure.

The Category 2 unserved locations typically are on roads that are long relative to the total number of potential broadband customers on the road. Comcast does not have business reasons to build

infrastructure on those roads; the potential return on investment is not great enough to prompt an investment in reaching the potential customers who live there. Given the low density of houses, too, Comcast is not obligated to build infrastructure on those roads under the terms of their Cable TV franchise agreement with the County, which only requires Comcast to provide service where there are 20 or more homes per mile from the closest Comcast hub site.[4]

Other Category 2 locations include pockets of multiple unserved homes surrounded by served areas. For the residents on these roads, which exist in locations in many parts of the County (as opposed to being clustered in contiguous geographic areas like the unserved homes in Category 1), this situation is particularly challenging; the cost of cable company line extension down their road—which the residents would be required to pay in order to get service from those companies—can be high.

There also exists a third category of locations within the County where homeowners struggle to get service, despite the presence of broadband infrastructure passing the home: premises set so far back from the road that the ISP has no obligation, under County franchise requirements, to build the service drop from the road to the user's premises (i.e., along the driveway) at no cost to the customer (referred to herein as "Category 3"). Although these homes are effectively unserved because many homeowners find the drop construction cost unaffordable, the homes are not considered "unserved" under federal and state definitions or with respect to eligibility for federal or state broadband grant funding.

We note that the category numbers do not indicate prioritization or emphasis in terms of the County's approach to filling its broadband gaps; the numbers are merely a convenient way to refer to the categories.

1.2.2 Economics of Rural Broadband

Unserved portions of Frederick County face the same challenges as other rural communities in attracting broadband infrastructure investment. Nationwide, even in the most affluent rural and semi-rural areas—from the horse farms around Lexington, Kentucky, to the ski communities outside of Aspen and Telluride, Colorado, to the resort areas on the Chesapeake Bay—the economics simply do not exist for rural broadband deployment absent substantial government funding. The private sector will not build costly infrastructure to reach all homes and businesses in low-density areas simply because the potential return on investment is insufficient to justify the investment.

[4] The Comcast Franchise Agreement of 2018 defines the density of "occupiable residential dwelling units" under which Comcast is obligated to extend services to be 20 houses per mile as measure in strand feet from nearest point of infrastructure. See: "Cable Franchise Agreement Between Frederick County, Maryland and Comcast…" https://frederickcountymd.gov/7392/Frederick-County-Comcast-Cable-TV-Franch (accessed June 2020).

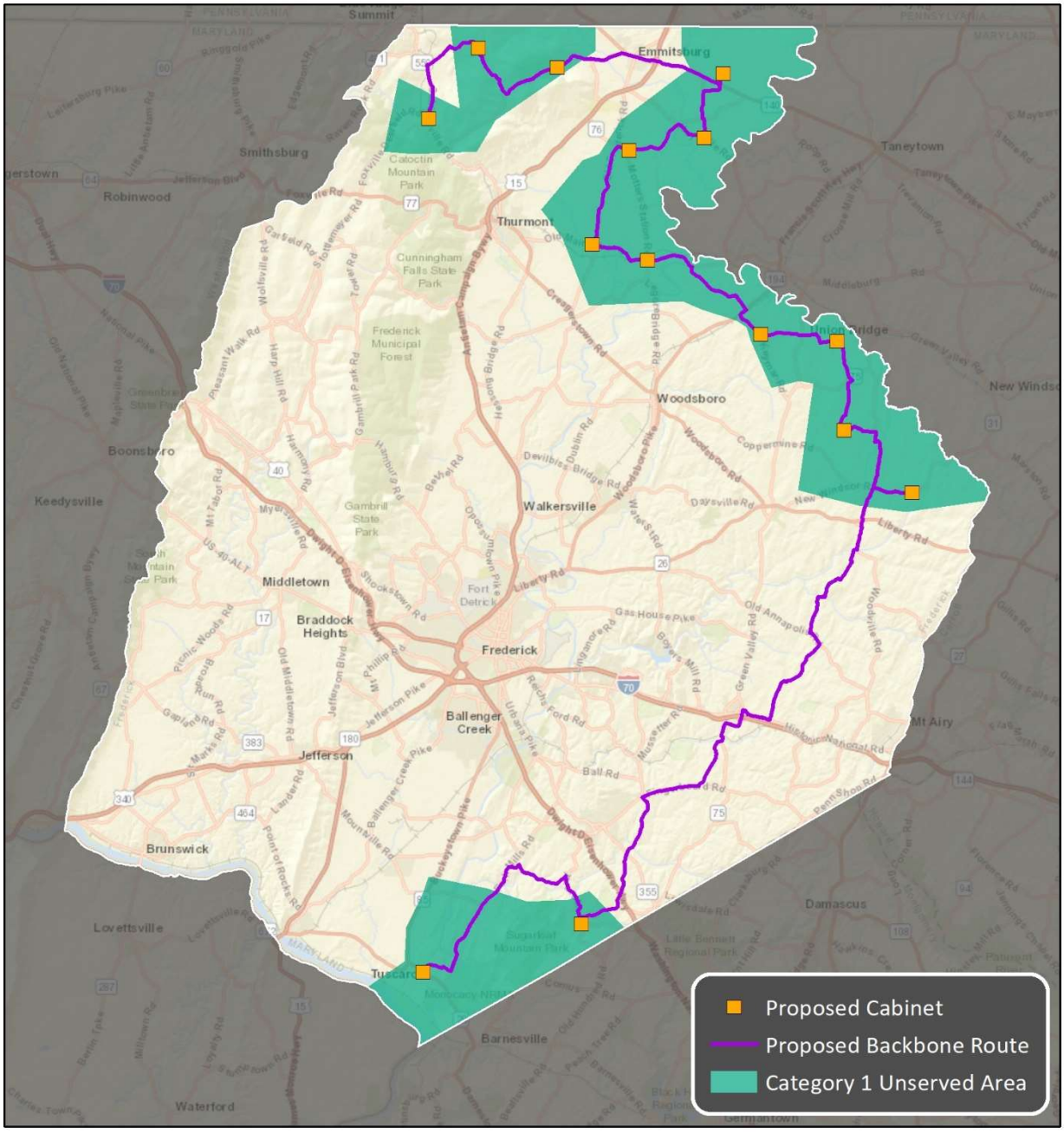
The same dynamics apply to virtually all areas of rural infrastructure development. In the case of broadband, the issues are starker because broadband is traditionally thought of as an area of private investment, rather than public investment. The challenging economics result from the lack of density of homes—and, in many cases, the fact that homes are located on large parcels of land; long driveways or setbacks from the road greatly increase the cost to deploy wired infrastructure to those homes.

1.2.3 Estimated Cost of Building Fiber-to-the-Premises in Contiguous Unserved Areas

Constructing fiber infrastructure to Category 1 unserved portions of the County would require a total capital investment of approximately $20.5 million. Considering only the outside plant infrastructure costs—not the service drops to the premises or the customer premises equipment—the network would cost approximately $5,250 per property passing. These estimates are based on conceptual-level engineering for serving Category 1 unserved premises; this planning-level design considers a range of factors that affect deployment costs, from the availability of utility poles to the number of fiber route miles necessary to pass all unserved homes and businesses. (Actual costs will also vary from this estimate due to factors that cannot be precisely known until the detailed design is completed, or until construction commences.) Section 3 describes this cost estimate in more detail. The costs would be lower for Comcast because it has network presence around all the areas.[5] The map below shows the conceptual design on which the cost estimates were based.

[5] Comcast was not responsive to multiple efforts to engage with the County. The County reported that they have courted Comcast for several years, but the company has shown no interest in partnership discussions.

Figure 3: Conceptual Backbone Fiber Design



1.2.3.1 Fixed Wireless for Contiguous Unserved Areas

As an alternative to deploying fiber-to-the-premises, a fixed-wireless network could be used to deliver broadband services to unserved Category 1 areas. CTC's engineers developed a candidate model to assess the viability of serving unserved Category 1 addresses with a fixed wireless network using existing government and commercial towers within the County.

Our analysis found that a fixed wireless network could be used to serve a portion of the County's unserved Category 1 homes and businesses—but it would have clear technical limitations relative to a fiber optic network, would not reach all unserved premises, and would be significantly more expensive *to operate* than a fiber network. While fiber-to-the-premises would be able to serve all of the County's Category 1 unserved homes and businesses, fixed wireless could only serve approximately 36 percent of those premises (with antennas mounted on existing towers).

1.2.3.2 Fiber Solution Preferable Over Fixed Wireless

Based on engineering and cost-estimation for the fiber-to-the-premises and fixed wireless solutions for Category 1 unserved portions of the County, we conclude that overall, fiber-to-the-premises represents a better broadband solution than fixed wireless for most unserved areas.

Taking into account the ongoing maintenance costs for each type of network—including tower lease fees and regular equipment replacement for the fixed wireless solution—the total long-term cost of ownership for a fiber-to-the-premises network would be lower than for a fixed wireless solution.[6]

1.2.3.3 Public-Private Partnership Opportunities

Based on our discussion with the private sector, we believe there is opportunity for the County to address some of these challenges while sharing risk with the private sector—and indeed, ideally substantially transferring most of the risk, and all technical operations, to the private sector. We make recommendations below about potential partnerships, but note that the County could also seek additional partnership opportunities through a request for information (RFI) or request for proposals (RFP) process. As we explain in the discussion of potential partnerships below, we recommend the County partner with entities that have some or all of the following attributes:

- First, capability and experience in cost-effectively building communications infrastructure. These capabilities can range from demonstrated experience to ownership of the poles (which conveys structural benefits and enables lower-cost construction) to existing communications infrastructure in the area, such as fiber optic or coaxial plant.
- Second, a partner with demonstrated experience as an internet service provider. Our experience is that USDA in particular requires a showing of such experience for funding grants—and it certainly conveys additional benefits for any state or federal grant application.
- Third, a strong and experienced management team.

[6] Section 5 provides a comparison between fixed wireless and fiber-to-the-premises.

- Fourth, a track record in successfully applying for state or federal grants or both. This is a demonstration of the fact that grant makers have already vetted the company and approved its capabilities.
- Fifth, experience partnering with local governments and a clear willingness to work collaboratively with a local government on grant applications and toward shared goals.

1.2.4 Potential Private Partners

The County's fixed wireless providers all expressed willingness to explore partnership arrangements to deliver services in specific areas of the County. These potential partnerships may provide options for reaching the unserved clusters remaining at the end of a multi-phase approach to address unserved areas with fiber or cable technologies (i.e., to deliver service where the more robust fiber or cable services cannot reach).

In addition to Comcast, whose footprint in most of the County would make them a natural partner to extend their current infrastructure, ThinkBig Networks participated in a number of conversations with CTC and were eager to explore ways to partner. A private partner, such as ThinkBig, is a promising option in what otherwise is a challenging landscape for finding high-speed broadband partners.

Such non-incumbent private partners could be at least a partial solution to the County's unserved areas, and also introduce some welcome competition in the future. Such partners could potentially use any investments in the County to spread further into both unserved and Comcast-served areas. A non-incumbent such as ThinkBig would likely require more County support than an incumbent, because non-incumbents need to build or lease infrastructure to the unserved areas. That includes backhaul to an existing point of presence on their network and a backbone fiber route from which to build distribution fiber into residential areas.

One notable exception to the discussions about partnerships and expansion is Verizon, which has not expressed interest in extending its small pockets of Fios service in the County. That follows the company's national pattern of only filling in small pockets in existing service areas. While Verizon did not engage with the County in discussions about partnership arrangements, a decision by Verizon to explore expansion in the County would be welcomed—especially considering its existing footprint in the larger Washington, D.C. metro market.

1.2.5 Federal and State Funding Opportunities

Federal and state funding sources represent an important element of large-scale broadband deployments for unserved areas. While these programs tend to have restrictions that affect their potential breadth of impact, our analysis is that a number of programs—including Maryland's rural broadband grant program and the federal ReConnect and Rural Digital Opportunity Fund

programs—could assist the County's efforts to reduce the number of unserved homes and businesses.

First, USDA's ReConnect program represents the most significant congressional appropriation of broadband funding since the Recovery Act in 2009—with $550 million made available for the 2020 round two rollout, $100 million added in emergency funding,[7] and likely annual future appropriations. The program awards loans, grants, or a combination of the two for last-mile connections in rural areas; it favors applicants that demonstrate both experience in network operations and strong support from the local government in the area to be served. The round-two application window closed April 15, 2020,[8] but industry and Washington observers expect future congressional appropriations for what is considered a well-run and popular federal broadband program.

Second, the FCC's Rural Digital Opportunity Fund will be awarded through a reverse-auction process (in which the lowest bidder wins) that will take place starting October 27, 2020. The FCC plans to award up to $20.4 billion—including $16 billion in the first phase, then conducting another auction to award whatever funds remain from Phase I, as well as the remaining $4.4 billion. These funds will be disbursed over the next decade in periodic increments to support the buildout and operation of high-speed broadband networks in unserved areas of the country. The short-form application for participation in the Phase I auction closed July 15, 2020; we expect Phase II to be announced sometime after the conclusion of Phase I awards. Here too, there is a strong possibility that Congress will appropriate additional funds for the Phase II auction.

Third, Maryland's Office of Rural Broadband released the application for a broadband grant initiative that explicitly seeks to complement federal and local funding sources—an approach that could enable an entity partnering with the County to use the state's funding as a match for a federal ReConnect grant application, or to enable a lower bid in the Rural Digital Opportunity Fund reverse auction. The state plans to award grants of $1 million to $3 million from a total funding budget of at least $9 million. Applications were due by February 21, 2020. However, the Office sees this as a multi-year campaign, and a new round of funding is expected to be announced towards the end of 2020, with an application window closing in early 2021.

[7] "USDA Implements Immediate Measures to Help Rural Residents, Businesses and Communities Affected by COVID-19," USDA Rural Development, News Release, April 15, 2020, https://www.rd.usda.gov/sites/default/files/USDA_RD_SA_COVID19_CUMULATIVEUpdate04152020.pdf (accessed April 17, 2020).

[8] "USDA to Make $550 Million in Funding Available in 2020 to Deploy High-Speed Broadband Internet Infrastructure in Rural America," U.S. Department of Agriculture, News Release, Dec. 12, 2019, https://www.usda.gov/media/press-releases/2019/12/12/usda-make-550-million-funding-available-2020-deploy-high-speed (accessed December 13, 2019).

Lastly, there is likely going to be infrastructure- and/or broadband-specific funding available through future Covid-19-related congressional appropriations. These could be funneled through existing federal grant programs (such as the U.S. Department of Commerce's Economic Development Administration's emergency grant programs), special new programs, or pass-through block grants to states. We do not know the extent to which such future grants will require private partners, public infrastructure, and/or matching funds, but the funds are likely going to be distributed and expected to be expended rapidly in order to have maximal and timely impact. As we discuss next, the greater the extent to which the County can cultivate relationships to rapidly and creatively adapt partnership arrangements in target areas, the more likely the County will be able to take advantage of such opportunities.

1.3 Recommendations

1.3.1 Multi-Year Strategy

Our primary recommendation is that the County collaborate with private sector partners to apply for state and federal broadband grants, with the understanding that this effort may require multiple years and is unlikely to be resolved in the short-term. For example, we believe the Category 1 (contiguous unserved) areas present a potential opportunity for a partnership between the County and a private entity in which the private entity, with the County's support, will seek state and federal grant funds to build broadband across one or both of the unserved areas.

Our recommendations lay out a strategy and timeline for this approach beginning in 2020, with the understanding that there likely will be state and federal broadband funding in 2021 and beyond—and it may take years to access sufficient grant funds to address the entirety of the two unserved areas. (We note, however, that the Rural Digital Opportunity Fund does represent a unique opportunity for which time is of the essence, as the reverse auction will be held in late October and early November 2020 for a decade's worth of ongoing funding.)

While we cannot predict what partnerships and funding opportunities might come to fruition, we note that many different scenarios could play out—ranging from one entity building infrastructure to all of the County's unserved areas, to multiple entities each building in smaller parts of the unserved areas.

We also note there is no silver bullet that will solve the County's broadband needs. While some partners may be willing and able to take on the risk and financial burden with state or federal support alone, filling the broadband gaps will, in all likelihood, require a significant County investment as well.

The following are our recommendations for immediate, intermediate, and long-term steps the County can take in light of what we have learned in conducting this study, to begin to remedy the broadband challenges identified.

1.3.2 Partner with a Private ISP on State and Federal Funding for Category 1 Unserved Areas

CTC engaged with a range of potential private partners for this effort during preparation of this report. Of those entities, one that appears to be a suitable partner for the County is ThinkBig, a Maryland company that is operating fiber-to-the-premises in Kent County and parts of Baltimore. ThinkBig, and perhaps other similar companies, appears willing and engaged in preliminary discussions with the County—and could be a viable partner for state and federal grant applications to construct fiber to serve the County's unserved areas.

CTC recommends the County proceed with evaluating a partnership with a private partner, such as ThinkBig, to address the Category 1 unserved areas. Fully addressing these challenges is likely to be a multiyear effort, but first steps can certainly be taken in 2020. ThinkBig has indicated an interest in working with the County to apply for state and potentially federal grants—and has already engaged with the County in discussions.

The County's role would be to provide strong letters and other indications of support, as well as to facilitate and support the development of the grant applications and contribute to matching fund requirements. As is discussed above, we preliminarily anticipate that both the state of Maryland and the federal government will continue current rural broadband grant programs in coming years, so both state applications and ReConnect applications anticipated in early 2021 could be targeted.

Non-incumbent private partners face higher capital costs than incumbents because they need to build or lease connections back to their network core equipment and build new backbone and distribution fiber without being able to leverage existing fiber in the surrounding area. The County may therefore need to set aside a higher level of its share of financial support on grant applications. In exchange, the County could seek in-kind contributions. For example, reserving backbone fiber strands for County use to connect nearby County assets such as radio towers and fire stations could provide substantial benefits to the County. The County's current I-Net fiber is provided by Comcast under restricted use, which prevents the County from using it for economic development or other internal government purposes. Access to unrestricted fiber could increase options for the County (especially if the partner were responsible for maintenance). Other examples of potential in-kind contributions include free public Wi-Fi at key locations, and connectivity to a desired internet exchange point or data center.

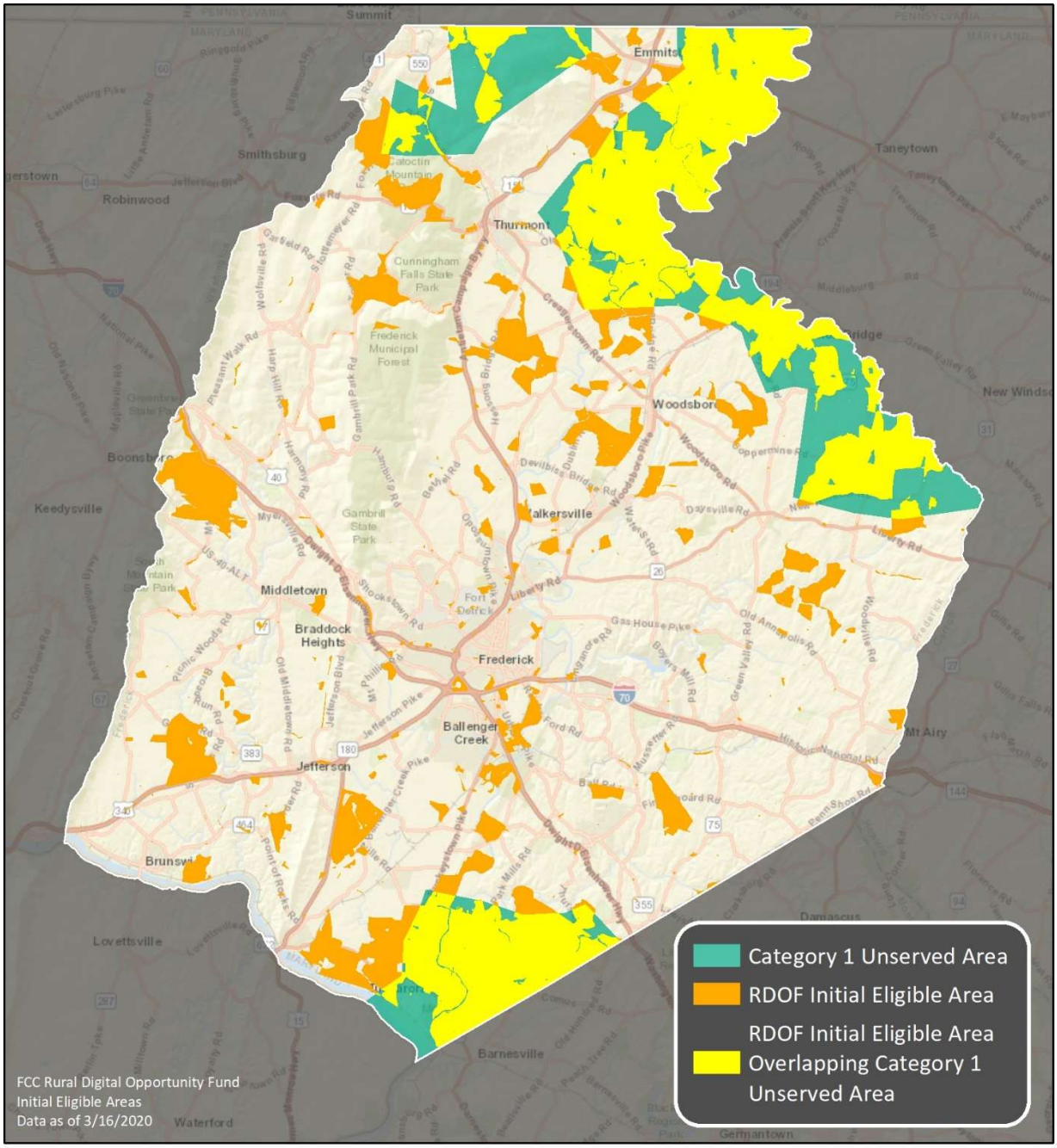
All of the grant programs are highly competitive. Many very deserving grant applications will not be funded simply because there are insufficient funds appropriated to meet the demand. So private partner applications may not succeed in their first efforts, but this is one of the reasons we recommend a multiyear strategy and a persistence in applying to these grant programs over time. Even if the initial set of applications is successful, the funding is unlikely to be sufficient to address all of the Category 1 unserved areas—further reinforcing the need for a multiyear effort and an expectation that that broadband solution will take time.

1.3.2.1 Consider Rural Digital Opportunity Fund and ReConnect Grant and Loan Programs

The FCC issued maps of the areas initially eligible for the Rural Digital Opportunity Fund (Figure 4); for Frederick, these maps seem to disregard the coverage claimed in Form 477 filings by fixed wireless providers. Freedom Broadband, for example, claims 25/10 coverage in small parts of the County (Figure 5, below), while Telegia Communications is claiming 30/5 in most of the County (Figure 6).

Existing providers had until April 10, 2020, to challenge these areas by claiming they had added coverage since June 2019; our review of posted challenges after this deadline found that neither of these wireless ISPs had mounted challenges. ThinkBig or a similar partner should therefore be able to apply for participation in the auction and compete for those areas, thereby potentially covering significant portions of the unserved Category 1 areas of the County (see Figure 4 below).

Figure 4: Unserved Areas and Census Block Groups Initially Eligible for Rural Digital Opportunity Fund[9]



[9] Initially eligible. These areas may change slightly after the FCC adjusts the maps to reflect challenges filed by existing providers prior to the April 10, 2020, deadline.

Figure 5: Freedom Broadband 25/10 Mbps Service Claims

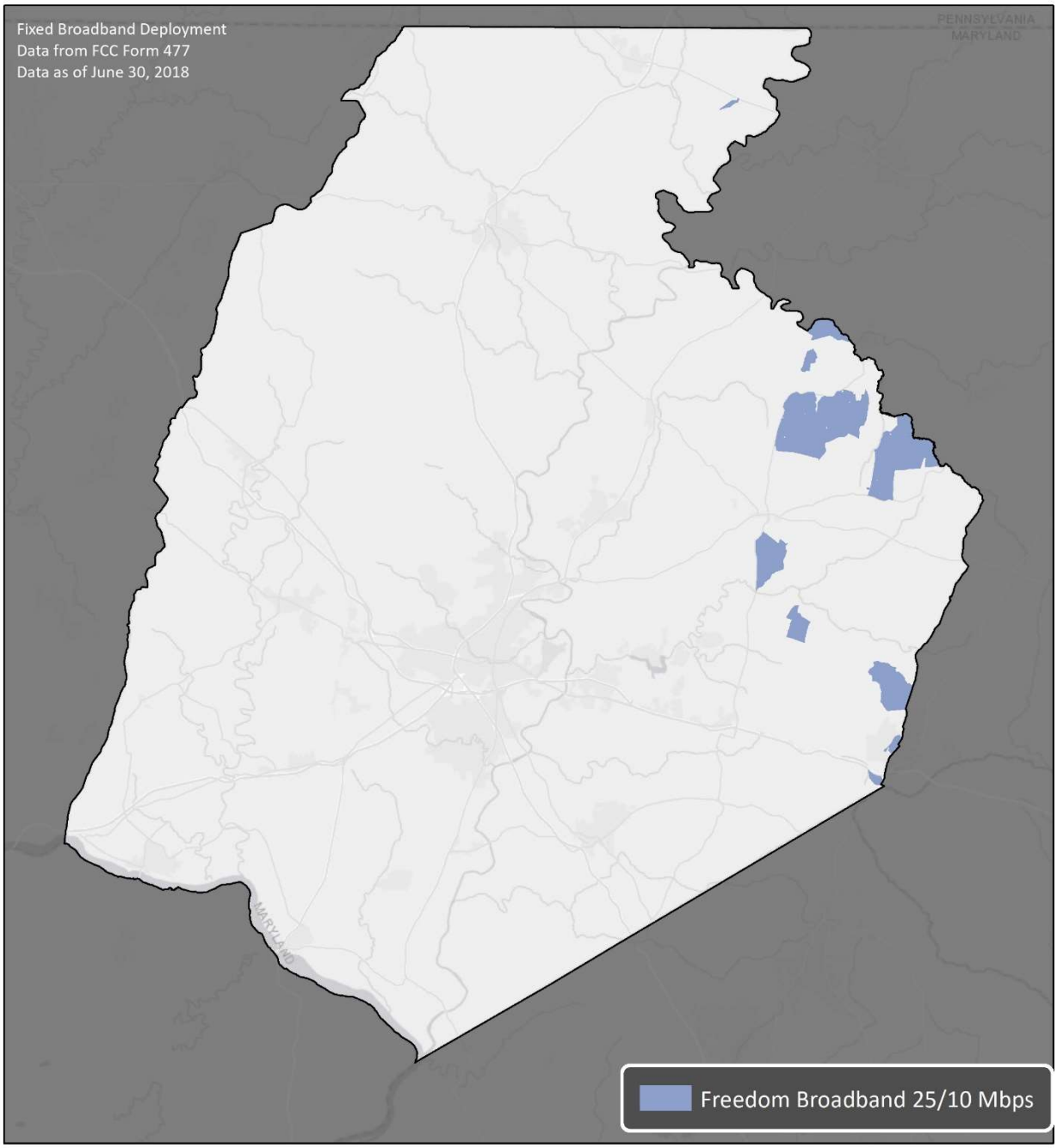
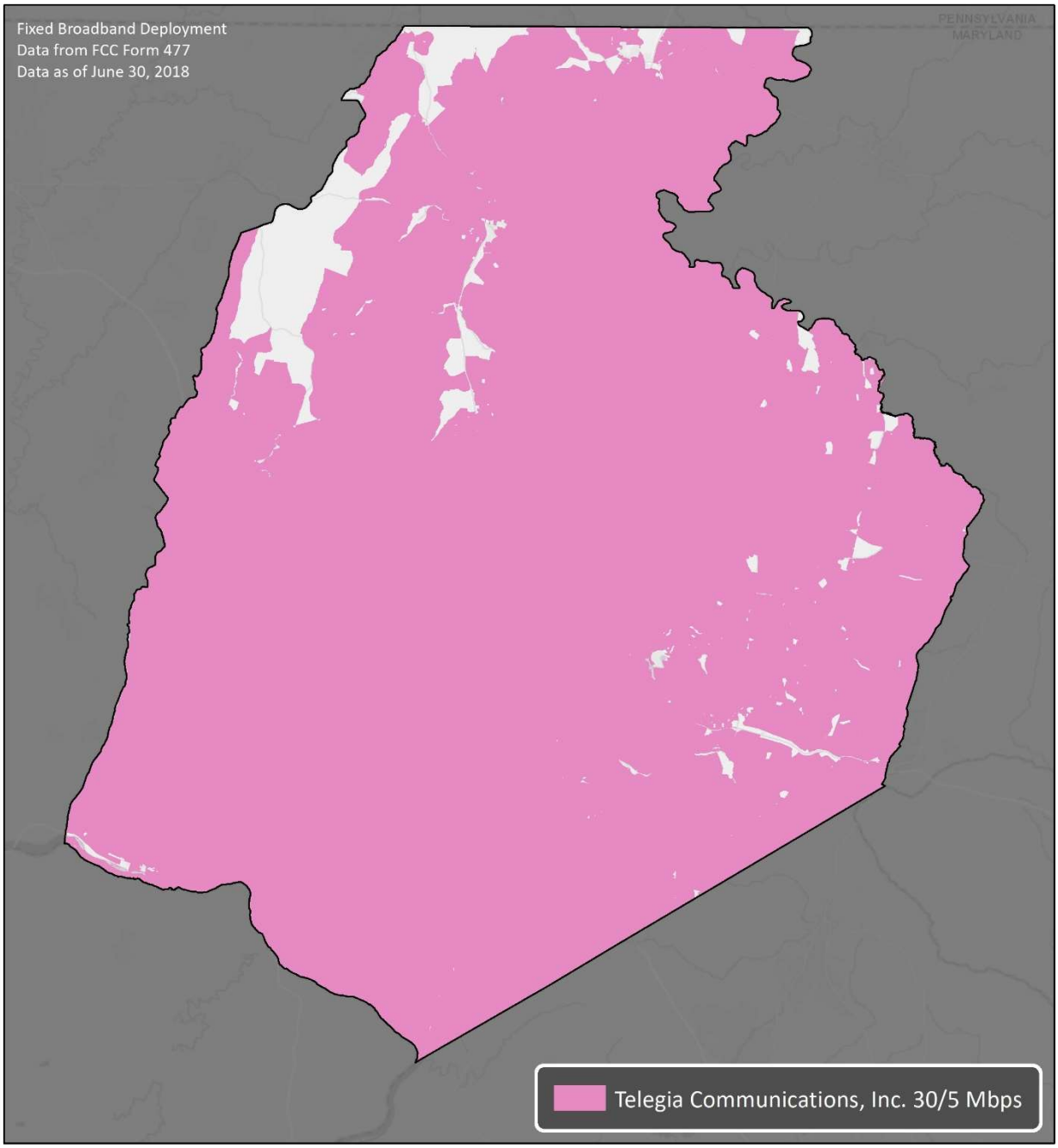


Figure 6: Telegia Communications 30/5 Mbps Service Claims



Unlike ReConnect and other traditional grant programs that encourage public-private partnerships and require jurisdictional participation—and potentially matching funds—the Rural Digital Opportunity Fund is an auction in which ISPs compete for future operational support funding. As such, we do not expect ISPs to enter into agreements with jurisdictions prior to participation in such auctions.[10] There are multiple reasons for this:

1) All things being equal, ISPs would prefer not having strings attached on their bidding strategies.
2) Funding, if awarded, is relatively generous, and the promise of a decade's worth of guaranteed support can act as security against which necessary capital funds can be raised (without jurisdictional participation).
3) Return on investment and network expansion calculations shape bidding strategies regardless of jurisdictional borders and may therefore not neatly align with a jurisdiction's Rural Digital Opportunity Fund-eligible census blocks.
4) Jurisdictions typically have public transparency and open competitive procurement requirements that justifiably make it difficult to enter into sole-source arrangements with a private partner; those same factors make it difficult for jurisdictions to comply with the requirement that information related to the auction not be disclosed during the period between the application for participation and the close of the auction.

That said, the County *can* consider incentives for competitive bidding on Rural Digital Opportunity Fund-eligible areas inside its jurisdictional borders on a non-exclusive basis. For example, it can set aside and announce a fund to support *any* provider that wins areas in the County and that bid on the highest speed tier (gigabit). This fund could take the form of a capital grant equal to (or as a percentage of) the awarded annual support. A provider interested in bidding on service to Rural Digital Opportunity Fund-eligible areas would thereby be incentivized to bid to serve parts of the County because it could count on getting some additional capital funds to help with the buildout.[11]

In addition to the Rural Digital Opportunity Fund, ThinkBig or a similar partner could also apply for state and ReConnect grants. The caveat in regard to ReConnect grants, and to a lesser extent state grants, is that a process would need to be established for challenging the fixed wireless

[10] We are not aware of such arrangements for the previous FCC auction on which the Rural Digital Opportunity Fund is based (i.e., Connect America Fund II).

[11] A variation on this could be to set aside the theoretical maximum annual amount of support possible under the Rural Digital Opportunity Fund, which would be equal to 100 percent of the Rural Digital Opportunity Fund reserve price set for those areas. (The actual percentage at which the auction will stop is likely to be somewhere around 60 percent to 80 percent.) The partnership agreement could then allow leftover funds to be disbursed against further expansion into non- Rural Digital Opportunity Fund unserved areas.

providers' claims that they serve most of the County with 25/3. See Section 1.3.6 for more details. As mentioned in Section 1.2.1, we do not find it credible that these fixed wireless providers are capable of uniformly providing this service in their claimed coverage areas. In order to position the County to take advantage of federal and state grants that rely on or take into account such self-reported claims form fixed wireless providers, we recommend the County commission a systematic wireless study to establish where the wireless providers can and cannot provide 25/3 service (or 10/1 service in the case of ReConnect).[12] Collecting baseline performance metrics on fixed wireless performance will also allow the County to work with these providers to pinpoint and address performance issues, and give the County a better picture of where fixed wireless can play a constructive role in expanding coverage to difficult-to-reach locations.

If ThinkBig, or a similar firm, were to miss the Rural Digital Opportunity Fund application window, it would still be eligible to apply for later rounds of state funding, and possibly ReConnect if its application includes a process for challenging fixed wireless providers' coverage and speed claims.

1.3.2.2 ThinkBig Is an Attractive Partner

CTC recommends ThinkBig as a suitable partner for the County for a number of reasons. First, ThinkBig's multiyear track record in fiber-to-the-premises deployment and operations, including on the Eastern Shore, means the company represents an able partner for the county. The company reports having constructed more than 40 miles of fiber in Maryland in the last couple of years. Based in Chestertown, ThinkBig offers fiber-to-the-premises gigabit connectivity in southern portions of Baltimore City (with plans to expand into the central city) as a competitive alternative to Comcast in those areas. In addition, ThinkBig has been working with Kent County to expand access to unserved rural areas supported by state grants, and has worked with Queen Anne's County to develop broadband partnership projects.

ThinkBig's track record will be in its favor as a potential partner. Based on our conversations with the funding authorities, only experienced entities are likely to succeed in applying for broadband grant funds. While ThinkBig is not a large company, its management team is experienced, it appears well-capitalized, and it holds a number of years of operating experience as a rural and urban ISP. These elements will be critical, non-negotiable components of a successful federal grant application.

Second, we recommend ThinkBig because it has a track record of successfully applying for rural broadband grants from the state of Maryland. That success record suggests that the state's grant-

[12] This might include collecting data from online speed tests performed by residents across the County; conducting premises-based speed tests at the homes of residents who volunteer to allow the County or its contractor to perform the brief tests; and conducting in-field speed testing at representative outdoor locations throughout the County.

makers have vetted the company and are comfortable with funding it. This factor appears to us to be a strong consideration in favor of the County selecting ThinkBig as its partner with an eye toward supporting the most viable and fundable potential partner.

Finally, we recommend ThinkBig because, while CTC engaged with a wide range of different potential private partners for this initiative, none of the others appear as viable for funding or as low-risk for the County. Whatever the amount the County invests in this initiative, either in the form of capital support or efforts to support its private partner's grant applications, we believe this selection is the most prudent for the County, and that ThinkBig's stability and track record, despite its modest size, would make the County's investment lower risk than would be the case with a company with less experience or capacity.

1.3.2.3 Partnership / Timing Considerations

Because Comcast has extensive existing fiber infrastructure in the County, it would likely incur the lowest cost to construct wireline broadband infrastructure to deliver service to the County's currently unserved areas. However, during the course of the preparation of this study, Comcast declined to provide information on their existing plant or future plans.

Firms like ThinkBig that are eager to get established in Frederick County may be more interested in considering projects in these areas. Although a company like ThinkBig will not have the lowest cost to build, because it does not have an existing proximate fiber infrastructure, it would potentially be competitive for state grant funding, federal ReConnect funding, or the Rural Digital Opportunity Fund. If a company like ThinkBig could successfully secure a state grant or support from the County, it could potentially position itself to obtain future Rural Digital Opportunity Fund funding. However, such an arrangement would need to satisfy the Rural Digital Opportunity Fund requirement that the areas bid on have not previously been subsidized by the state or County—meaning the County or state support should be concurrent or subsequent to a Rural Digital Opportunity Fund award. (As noted in a Section 1.3.2.1, it would also need to be structured as a partner-agnostic arrangement open to any bidder that wins in the auction and satisfies the County's requirements, such as limiting eligibility to gigabit service only.)

Given the timing for both state applications and ReConnect (the most recent application window closed March 16, 2020),[13] we recommend the County and ThinkBig consider developing the partnership with an eye toward 2021 grant opportunities to look beyond the upcoming Rural Digital Opportunity Fund auction. If ThinkBig or a similar partner were awarded state broadband

[13] "USDA to Make $550 Million in Funding Available in 2020 to Deploy High-Speed Broadband Internet Infrastructure in Rural America," U.S. Department of Agriculture, News Release, Dec. 12, 2019, https://www.usda.gov/media/press-releases/2019/12/12/usda-make-550-million-funding-available-2020-deploy-high-speed (accessed December 13, 2019).

funding, it could use those funds (and any County contribution to that program's match requirements) as its match for the federal application.

The County should also engage with ThinkBig or a similar partner to discuss potential collaboration around any upcoming Covid-19 related funding. Depending on how appropriations are channeled by Congress, such funding may require public ownership of the funded infrastructure. Projects could therefore take the form of middle-mile fiber that can act as cheap backhaul and distribution plant allowing ThinkBig (and any other interested broadband provider) to enter into new unserved areas. If the County is uncomfortable with owning such infrastructure, it could potentially partner with the Maryland Department of Information Technology which already operates an extensive infrastructure, or with Maryland Broadband Cooperative which has significant flexibility in entering into creative and productive partnership arrangements.

1.3.3 Continue to Encourage Comcast to Pursue State Funds for Category 1 and Category 2 Unserved Areas

As noted above, Comcast would be the County's natural partner for an effort to extend wireline broadband into unserved areas. However, our discussions with the County have indicated that Comcast has very limited interest in extending their infrastructure into more rural areas of the County. That said, we believe the County should continue to pursue a potential partnership with Comcast to address Category 2 unserved locations and portions of Category 1 locations that are outside of ThinkBig's target areas.

As is discussed in this report, isolated, low-density roads within areas that are otherwise served by Comcast do not present a compelling business case or opportunity for a new provider. In addition, the full areas are not eligible for state or federal funding because much of these areas are already served—further reducing the interest of new entrants to build in those areas.

Comcast, however, is positioned to cost-effectively expand its infrastructure to those unserved pockets within its served areas, and both state and federal funding sources are available to them for this purpose if they choose to apply. For example, the state of Maryland late last year opened a grant opportunity for these "line extensions" by incumbents such as Comcast (see Section 6.2). That particular grant opportunity has already closed, but we fully expect that the state will create new opportunities of that sort annually and potentially even more frequently, particularly if the companies show interest.

Further, the state's previous, and expected future, grant opportunities, as well as future federal ReConnect opportunities, allow companies to apply for funds to build on multiple isolated roads within a larger geographic area (i.e., file on an aggregated basis for a single grant to build on unserved roads within their existing served footprints).

The areas to which Comcast may be interested in extending have clusters of premises that would likely provide a better return on investment than would serving less densely clustered customers, especially given a subsidized arrangement with grants and matching funds that bring the capital costs within a regular range.

1.3.4 Work with Other Interested Fiber Providers

A few smaller fiber-to-the-premises providers have expressed that they plan to adopt business models similar to ThinkBig's—identifying an affordable way to extend their networks from a current point of presence into a targeted area, then building a distribution network. Such providers generally are more flexible than incumbent cable companies and are able to lower costs with innovative approaches to construction, electronics, or operations—but they typically require a higher level of support from local jurisdictions to make the economics work for them.

We recommend the County consider partnering with a provider such as one of the following entities after the company has established a successful operational track record—so engagement in the near future is therefore likely premature.

Talkie Communications, headquartered in Chestertown, Maryland, has discussed partnering opportunities elsewhere in Maryland, including an expansion from their current presence in Chestertown across the river into Kingstown in Queen Anne's County.

Last Mile Broadband, headquartered in Clinton, Maryland, similarly expressed interest in exploring partnering arrangements in Maryland jurisdictions. Unlike ThinkBig and Talkie, however, they had less concrete plans in mind, and we were unable to establish whether Last Mile has any current network presence. While this does not mean the County should not engage with Last Mile, the company's lack of a construction and operational track record poses a risk to any County investment—and makes the company less competitive for grant opportunities such as ReConnect and state grants in which operational experience factors strongly into the evaluation.

That said, Last Mile could be a viable partner for the County down the road in a multi-year strategy. Their stated approach is to build either fiber-to-the-premises or hybrid fiber/fixed wireless solutions.

1.3.5 Consider Partnerships with Fixed Wireless Providers

Given our analysis of capital and operating costs and the challenge in consistently providing the needed performance (see Section 3), fixed wireless deployment would not be our first recommendation for filling the County's service gaps. That said, the technology is feasible and, if the County were to identify a suitable partner, using fixed wireless might be a suitable option for serving some homes and businesses.

Fixed wireless could be the most realistic option for serving the County's most remote areas (i.e., after other partners have claimed areas where fiber-to-the-premise works for them). What will remain, assuming the efforts to fill in denser unserved areas are successful, would have much higher average costs per property passed, so the fixed wireless approach could therefore offer a cost-effective solution. This could situate Telegia or Freedom Wireless as potential partners targeting the County's remaining unserved areas.

Whether Telegia, Freedom Wireless, or another entrant would be the best candidate depends in part on the spectrum they use, the proximity and placements of tower assets, and their backhaul capacity and design; the County should evaluate any partnerships in light of these technical aspects (as well as their future plans for technology upgrades and new tower assets).

Telegia, in particular, could—under the right conditions—be an effective partner for reaching the County's unserved areas. Telegia is headquartered in Frederick, so this is its home turf. And unlike other fixed wireless operators it has access to licensed spectrum, which is less susceptible to interference.

Telegia's ability to improve performance and coverage rests on access to tower assets, either in the County or across the border in adjoining counties. For small operators such as Telegia, getting long-term, reliable access to government tower assets at low or no cost would make a big difference in the business case—because tower lease costs represents a large portion of a fixed wireless operator's costs.[14]

In the course of preparing this report, CTC reached out to a number of fixed wireless companies that indicated interest but did not provide any concrete information regarding areas in which they would be interested or terms of a partnership with the County. Given the lack of an immediate partner and the preferability of fiber for this effort, we recommend that the County consider fixed wireless as a fallback option or last resort in the event other strategies proposed herein do not materialize.

1.3.6 Collect Additional Speed Test Data

To protect the County's interests and available partnership and funding options, we recommend the County consider conducting a broadband speed test data collection survey to document residents' actual service speeds. These data will be important if a fixed wireless provider is the

[14] Cost sharing in erecting new towers – with or without federal funding – could be another possible approach for creative solutions that could fill the County's own internal needs for public safety, and also provide low cost access for fixed wireless providers. Should the County gain access to an internal fiber optic infrastructure that is not franchise agreement derived – and thus unrestricted – it could offer both fixed and wireline operators reduced or in-kind exchanged access which would significantly reduce their costs to reach target areas in the County. Telegia is using Comcast, Shentel, and microwave for backhaul. In other Maryland jurisdictions, affordable Maryland Broadband Coop or jurisdiction owned fiber is used where feasible for backhaul by such providers.

winning bidder on the areas eligible for the Rural Digital Opportunity Fund—or if the bidding significantly lowers the percentage of the reserve price and the County's partner (whether that is ThinkBig or a similar company) decides to opt out of the auction.

As mentioned in Section 1.2.1, we do not find it credible that fixed wireless providers, including Telegia and Freedom Wireless, are capable of uniformly providing 25/3 service in their claimed coverage areas. In order to position the County to take advantage of federal and state grants that rely on or take into account such self-reported claims form fixed wireless providers, we recommend the County commission a survey to establish where the wireless providers can and cannot provide 25/3 service (or 10/1 service in the case of ReConnect).[15] Collecting baseline performance metrics on fixed wireless performance will also allow the County to work with fixed wireless providers to pinpoint and address performance issues, and give the County a better picture of where fixed wireless can play a constructive role in expanding coverage to difficult-to-reach locations.

[15] This might include collecting data from online speed tests performed by residents across the County; conducting premises-based speed tests at the homes of residents who volunteer; and conducting in-field speed testing at representative outdoor locations throughout the County.

2 Detailed Analysis of Unserved Properties

2.1 Approach

We began our analysis by evaluating unserved areas where no wireline infrastructure capable of delivering services that meets the federal and state definitions of broadband passes[16] homes and businesses—meaning there is no cable or fiber plant in the right-of-way adjacent to the property.

We identified these unserved areas through a desk survey, in which a CTC outside plant engineer analyzed Google Earth Street View maps where available—searching images of miles of County roadways for the presence (or lack thereof) of broadband infrastructure such as cable attachments on poles (for aerial construction) and handholes and pedestals (for underground construction). Based on the sample or roads "driven" in the desk survey (Figure 7, below), the engineer extrapolated an estimated area where homes and businesses are unserved by broadband.

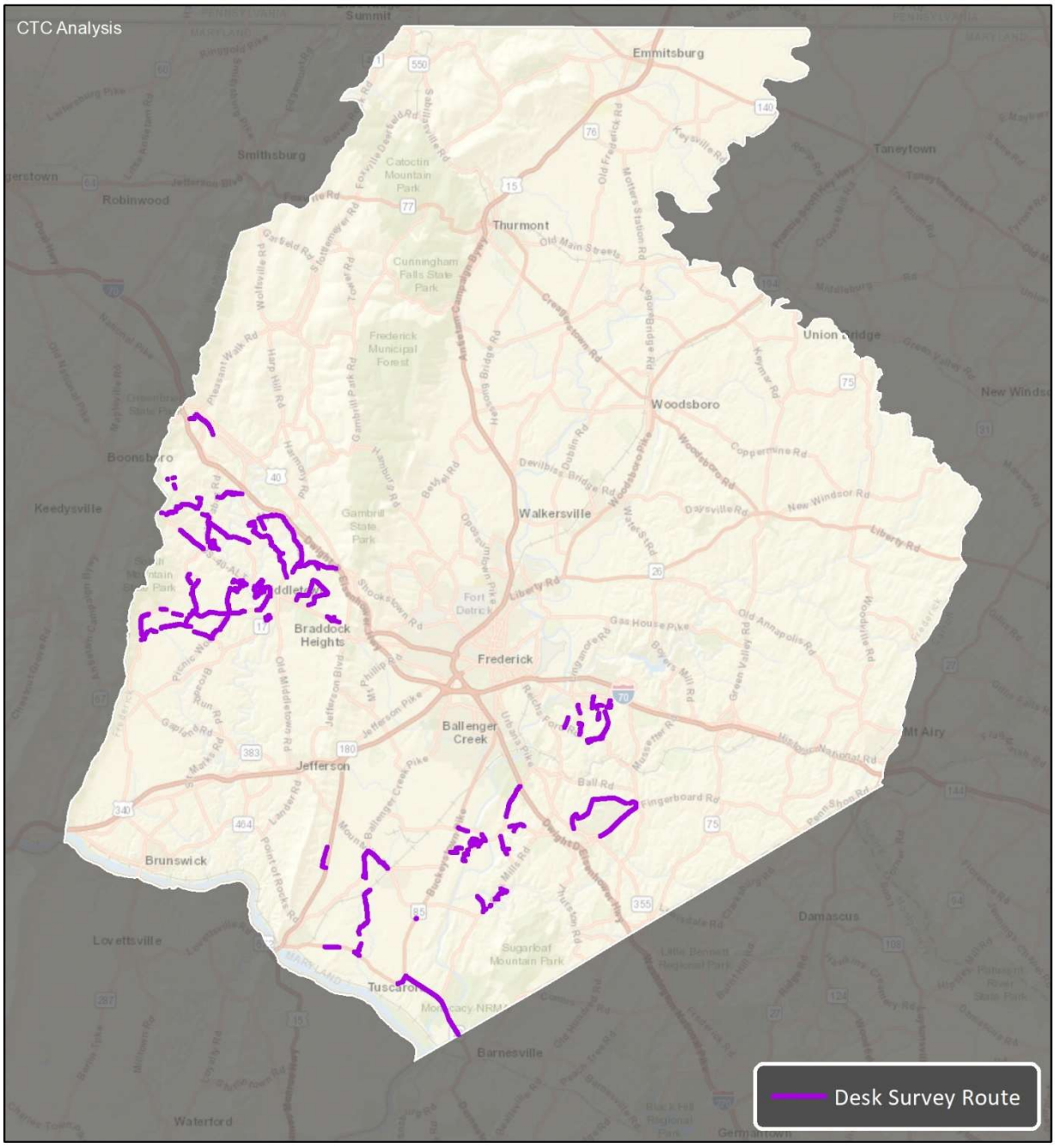
Our mapping and analysis identified approximately 3,000 homes and businesses unserved by wireline broadband infrastructure in contiguous unserved areas of the County (Category 1). A second group of unserved residents live at addresses on isolated unserved roads (Category 2).[17]

There is an additional category of locations within the County (Category 3) where homeowners struggle to get wireline service, despite the presence of broadband infrastructure passing the home: premises set so far back from the road that the ISP has no obligation to build the service drop from the road to the user's premises at no cost to the customer. Although these homes are effectively unserved because many homeowners find the drop construction cost unaffordable, the homes do not fit into the category of unserved for purposes of federal or state grant funding.

[16] A "passing" is the infrastructure that "passes" a home or business along the public rights-of-way, but it does not include the "service drop"—the portion of the network that connects from the road to the home or business itself. The availability of a passing to a home or business is the universally understood definition of what is served, both within the industry and among the state and federal government entities that fund broadband expansion[16] and regulate communications services.

[17] We note that the category numbers do not indicate prioritization or emphasis in terms of the County's approach to filling its broadband gaps; the numbers are merely a convenient way to refer to the categories.

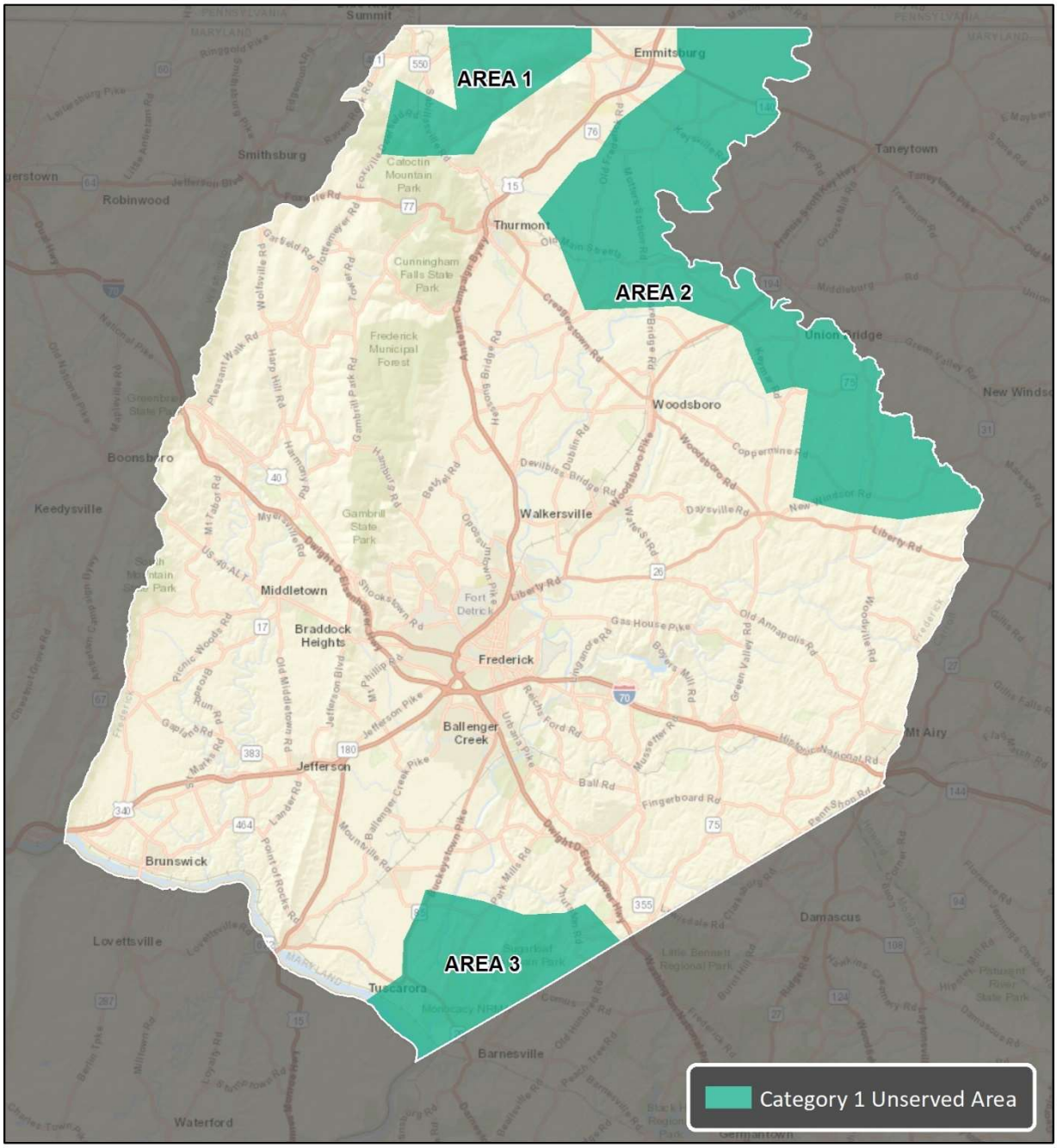
Figure 7: Desk Survey Routes



2.2 Unserved Category 1: Contiguous Geographic Areas

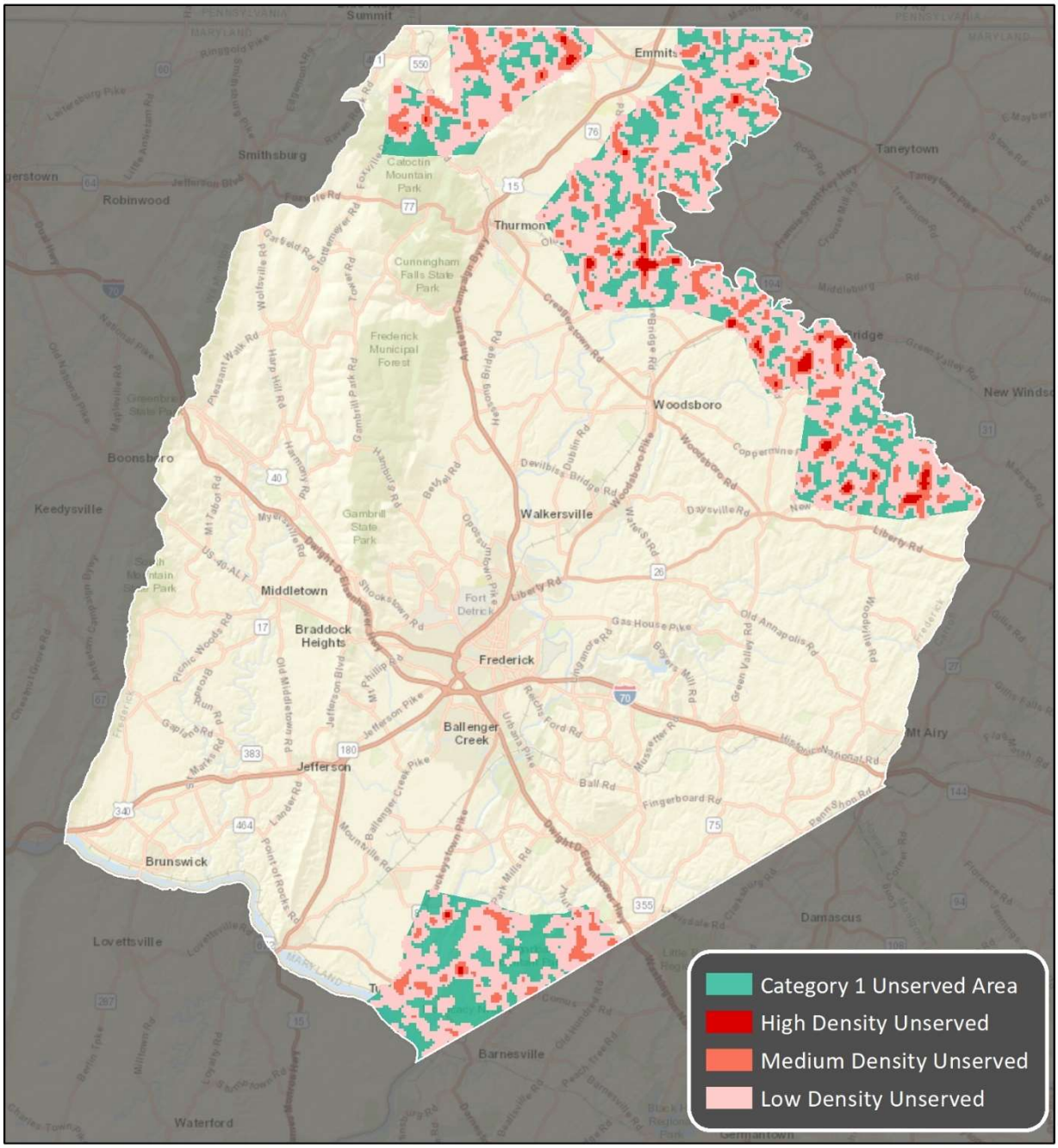
Category 1 comprises contiguous geographic areas where our desk survey estimates there is no wireline infrastructure capable of delivering broadband speeds. Based on CTC's analysis of available data and our desk survey, we determined that the County has approximately 3,000 unserved locations in this category (Figure 8).

Figure 8: Category 1 Contiguous Unserved Areas



As a further step in our analysis of Category 1 unserved areas, we used the County's address data to develop a heat map of population density in the Category 1 areas (Figure 9). We developed the heat map of address points with a GIS mapping tool, which divided clusters of addresses into three groups relative to the County's overall density. High, medium, and low are therefore relative values denoting level of clustering.

Figure 9: Category 1 Population Density Heat Map



2.3 Unserved Category 2: Addresses on Isolated Roads

Category 2 comprises the unserved premises located on isolated, low-density roads that fall within areas that are otherwise served. In other words, while the larger areas around these homes are generally served, the homes are on roads that do not have infrastructure.

The isolated unserved premises are typically on roads that are particularly long relative to the number of potential broadband customers on the road. Comcast has not had business reasons to build infrastructure on those roads because their potential return on investment is not great enough to prompt an investment in reaching the potential customers who live there. Given the low density of houses, too, the cable companies are not obligated to build infrastructure on those roads under the terms of their cable franchise agreements with the County.

Other Category 2 locations include pockets of multiple unserved homes surrounded by served areas. For the residents on roads like these, which exist in locations in many parts of the County, this situation is particularly challenging; the cost of a cable company line extension down their road—which the residents would be required to pay in order to get service from those companies—can be high.

The County may be able to work with incumbent providers to seek grant funding to lower the cost to these providers for extending service to these isolated roads. A new broadband provider would likely not be as interested in serving these isolated roads because it would not have existing plant adjacent to the isolated roads.

2.4 Unserved Category 3: Addresses with Long Driveways

In addition to the two categories of unserved residents, we also identified a third category of properties that do not have broadband service. These are customers for whom the cost of installation of the service drop—the connection from the right-of-way to the user's premises—is so high as to make service infeasible. This generally refers to locations where the home or business is more than 300 feet away from the road—that distance being the typical limit for cable franchisees' obligations to install a service drop at no cost to the customer.[18]

Although CTC and the County have not counted the number of properties in this category, and thus do not know whether the category comprises a significant number of homes, we recognize that this cause for lack of service could be a source of frustration. County residents with such long setbacks often cannot afford the cost of service drop installation that Comcast would assess. That means they are effectively unserviceable—even if fiber passes their property and they are considered to be "served with broadband" by the state and federal governments.

Service to these homes or businesses is a matter of the affordability of drop construction, not availability of infrastructure. The County could choose to subsidize the cost of drop construction, but this is unfortunately an area in which the County will not have a state or federal partner to

[18] The County's 2018 Franchise Agreement with Comcast requires the company to make service available to homes within 300 feet of the public right-of-way. This distance tends to be the upper limit in franchise agreements; some franchise agreements have lower thresholds for scenarios in which cost is shared with customers.

solve that problem—because neither state nor federal grant funding applies to building service drops to these locations.

2.5 State and Federal Funding Applicable to Unserved Category 1 and 2 Areas

With an understanding that state and federal funding may represent a viable opportunity for enabling the County's efforts to fill broadband gaps in Category 1 and Category 2, we also evaluated FCC Form 477 data about broadband services available in the County—both at the 25/3 and 10/1 levels. We note that while the County is concerned about lack of service that meets the FCC's definition of broadband (25/3)—and that 25/3 is the threshold for the State of Maryland's broadband funding—the USDA's ReConnect grant and loan program currently uses 10/1 service availability as its minimum definition.

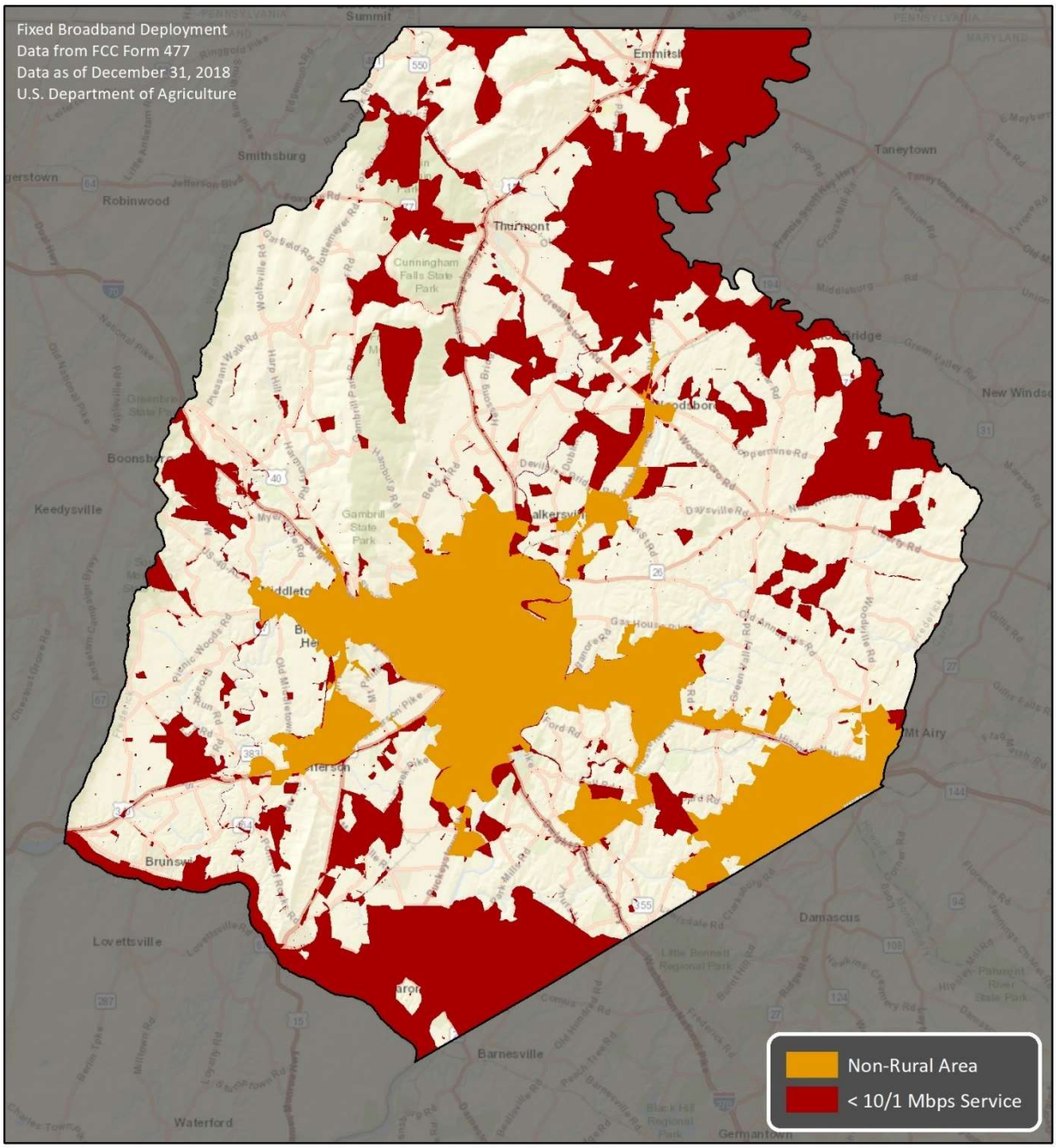
For purposes of identifying ReConnect-eligible areas at a high level, the following map illustrates the areas lacking 10/1 wireline service (i.e., fiber or coaxial cable) as reported on Form 477 (Figure 10, below). Under current ReConnect rules, an applicant's proposed funded service area (PFSA) is eligible if 90 percent of the area lacks access to 10/1 service.

Areas eligible for ReConnect grants typically are smaller than the more expansively allowed areas for state grants. In addition to adopting a higher allowance for grant eligibility, state grants also do not exclude previously funded areas from eligibility. However, not all these areas are necessarily eligible for state funding, because the state's service threshold for eligibility is less than 25/3 in an entire geographic area, rather than just 90 percent.[19] In addition, the dark blue areas in the map only capture fiber and cable, but fixed wireless providers claim 25/3 in much of the County, which would need to be contested and/or verified to establish grant eligibility. Importantly, too, while the Form 477 data for the more conservatively drawn dark blue areas is a strong starting point, they are insufficient to prove that an area is unserved for purposes of being eligible for ReConnect funding. Under the ReConnect rules, an applicant is required to demonstrate that its PSFA is indeed unserved—and the USDA will conduct field verification of projects before approving them for funding.

Given the distribution of the County's Category 2 unserved premises, it is also important to note that ReConnect applications can aggregate isolated unserved addresses in rural areas—meaning an application to serve the County could include non-contiguous eligible unserved areas.

[19] If excluding the claimed coverage of fixed wireless networks and focusing only on wireline solutions, a 25/3 and 10/1 map is often identical in rural areas. This is because coaxial cable technologies typically deliver speeds exceeding not just 10/1 but also 25/3, unless it is very old cable plant intended only for one-way cable television transmission and not designed to carry internet. Fiber networks are always capable of delivering service in excess of both 10/1 and 25/3, which leaves DSL as the remaining wireline technology to be considered. Advanced DSL technologies capable of 10/1 or higher are fairly rare in rural areas because telephone companies typically do not invest in such technologies in sparsely populated areas.

Figure 10: Areas Potentially Eligible for ReConnect Funding Because They Lack 10/1 Service According to Form 477 Data

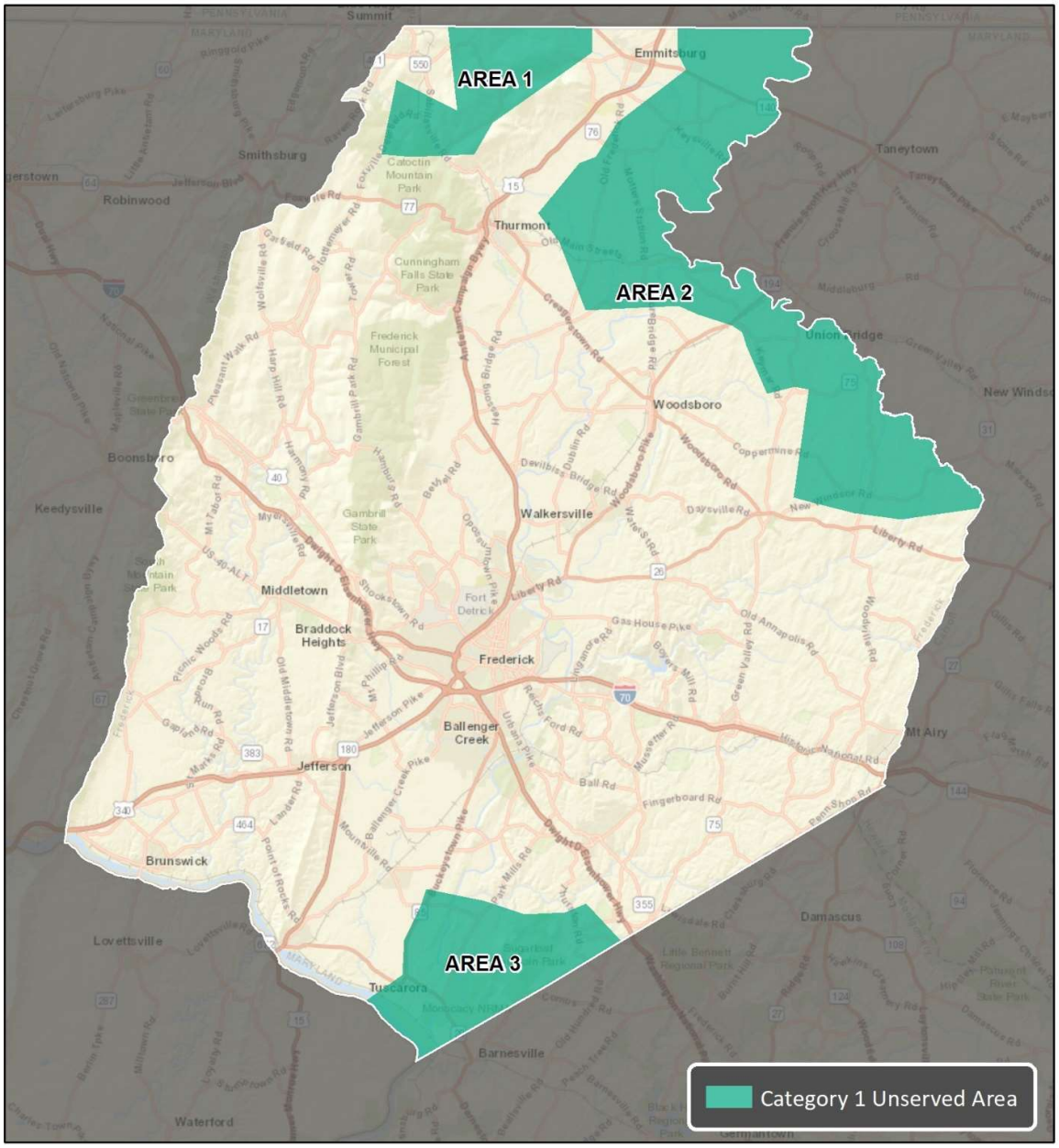


3 Fiber-to-the-Premises Infrastructure to Address Category 1 Unserved Areas

3.1 Overview

As documented in Section 2, CTC's analysis of County-provided data and our desk survey identified likely unserved areas with an estimated 3,000 Category 1 unserved homes and businesses (Figure 11) that could be served by a new internet service provider (ISP) or by the incumbent provider.

Figure 11: Category 1 Unserved Areas



As a candidate solution, CTC's engineers prepared a high-level network design for the deployment of a gigabit-capable fiber-to-the-premises network to serve Category 1 homes and businesses. We then estimated the cost for deploying that network, including a network backbone, assuming the construction was performed by the County or a partner entity that is not the incumbent telephone, power, or cable company.

The total estimated capital cost for the County or a partner to construct a fiber-to-the-premises network to serve the Category 1 areas is $20.5 million (assuming a take-rate—that is, the percentage of potential customers subscribing to the service—of 60 percent); details are shown in Table 1.[20]

Table 1: Estimated Total Fiber Deployment Cost for Category 1 Unserved Areas

Cost Component	Estimated Cost
Outside Plant	$16,800,000
Central Network Electronics	$800,000
Fiber Service Drop Installations	$1,900,000
Customer Premises Equipment	$1,000,000
Total Estimated Cost	*$20,500,000*

We estimated a cost per passing by dividing the outside plant cost by the number of passings. This is the cost of constructing fiber alongside the roads in front of unserved homes and businesses, divided by the number of homes and businesses—essentially the cost of building a network independent of connections to any specific homes and businesses. We estimate the average outside plant cost per passing will be approximately $5,250 (Table 2).[21]

[20] These numbers have been rounded. The take-rate affects the electronics and drop costs, but also may affect other parts of the network, as the County or its partner may make different design choices based on the expected take-rate. A 60 percent take-rate is possible in environments where a new provider delivers service in a previously unserved area. Market research would be required to estimate a more accurate take-rate at assumed service costs.

[21] In a joint grant application arrangement with a partner, the capital costs – and therefore the County's support – is exclusive of drop costs and customer premise equipment. Unless it is a brand-new network (such as when a county decides to build and operate a broadband network), central network electronics are part of the capital costs. In joint grant partnerships, incumbents and non-incumbents will typically backhaul the new builds to one or more existing central core sites. A non-incumbent will have added costs for the backhaul link and backbone/middle-mile fiber connecting unserved areas, that are often not grant eligible.

Table 2: Estimated Outside Plant Cost per Passing for Category 1 Unserved Areas[22]

Cost Component	Estimated Cost
Outside Plant	$16,800,000
Passings	3,200
Outside Plant Cost per Passing[23]	*$5,250*

These cost estimates—and the estimated operating costs described below (Section 3.6)—provide data relevant to assessing the financial viability of network deployment; they enable financial modeling to determine the approximate revenue levels necessary for the County or a partner to service any debt incurred in building the network. They also provide a baseline against which to evaluate the cost of incremental and non-fiber optic approaches, as compared to the cost of full coverage of the County's unserved areas with the highest-bandwidth technology.

3.2 Capital Cost Estimates

To develop and refine the range of assumptions that will have an impact on the network design and construction costs, a CTC engineer performed a desk survey of the County using Google Earth Street View. The engineer reviewed available green space and the presence and condition of utility poles. Based on this analysis, we developed customized estimates of per-mile costs for construction on utility poles and for underground construction where poles are not available.

Table 3 summarizes the conditions determined through our desk survey; the factors are described in detail below.

[22] Unrounded numbers are used in the engineering calculations; these are then rounded in the discussion.
[23] This is the average cost to construct the outside plant portion of the fiber-to-the-premises network for each home and businesses in the unserved areas.

Table 3: Construction Cost Factors Developed in Desk Survey of Unserved Areas

Cost Factor	Finding in Unserved Areas
Aerial Construction	95%
Poles per Mile	22
Average Moves Required per Pole[24]	1
Poles Requiring Make-Ready	2%
Cost Per Move	$350
Poles Requiring Replacement	1%
Average Pole Replacement Cost	$7,000
Intermediate Rock Underground	2%
Hard Rock Underground	1%

Make-ready is the work required to create space on an existing utility pole for an additional attachment. Existing attachments often have to be moved or adjusted to create the minimum clearance required by code to add an additional attachment. Each move on the pole has an associated cost (i.e., for contractors going out to perform the move). When a utility pole is not tall enough to support another attachment or the pole is not structurally capable of supporting the attachment, a pole replacement is required. The pole replacement cost is then charged to the new attacher.

Where utility poles do not exist, underground construction is required. One of the challenging variables with underground construction is the prevalence of rock. Softer stones and boulders (intermediate rock) require the use of a specialized boring missile that is more expensive than traditional boring. Hard rock requires even more specialized equipment such as rock sawing. The cost of boring through rock is added to the cost of traditional boring. We do not expect extensive hard or intermediate rock in the County, but some may be present.

CTC's outside plant engineer noted that the quality of the poles and pole attachments in the County varied, as they do in many cities and counties—but that overall, most of the poles have space for an additional attachment.

In many parts of the County's Category 1 unserved areas, the telecommunications cables (i.e., Verizon telephone lines) are installed on short telecommunications poles, typically on the opposite side of the road from electric distribution cables, which are installed on taller electric utility poles. The cost estimate assumes the County could attach to the utility poles in the

[24] The average moves per pole is the average number of existing attachments on the utility pole that need to be moved to create space and clearance in the communications space to support a new attachment for the fiber-to-the-premises network.

communications space below the electrical cables. Based on our experience, the County's utility pole lines appear more favorable for new pole attachment than the average utility pole—which will correspond to a lower-than-average aerial construction cost. In contrast, installing the fiber on the telecommunications poles would require substantial make-ready to make clearance for the attachment.

The figures below show samples of poles in various conditions in the County's Category 1 unserved areas. In Figure 12, for example, make-ready is required because the pole was replaced by the electric company but cables in the communications space still need to be moved to the new, taller pole (and need to be installed on the new pole to create clearance for the placement of fiber optic cable). This new utility pole appears tall enough that—with make-ready—another entity could attach to the pole.

Figure 12: Utility Pole Requiring Make-Ready

Tree trimming is required to add an attachment on the utility poles in Figure 13. Tree trimming is also an important maintenance function necessary to keep the pole line clear of tree limbs that could break or damage the wires on a utility pole.

Figure 13: Pole Line Where Tree Trimming Will Be Required

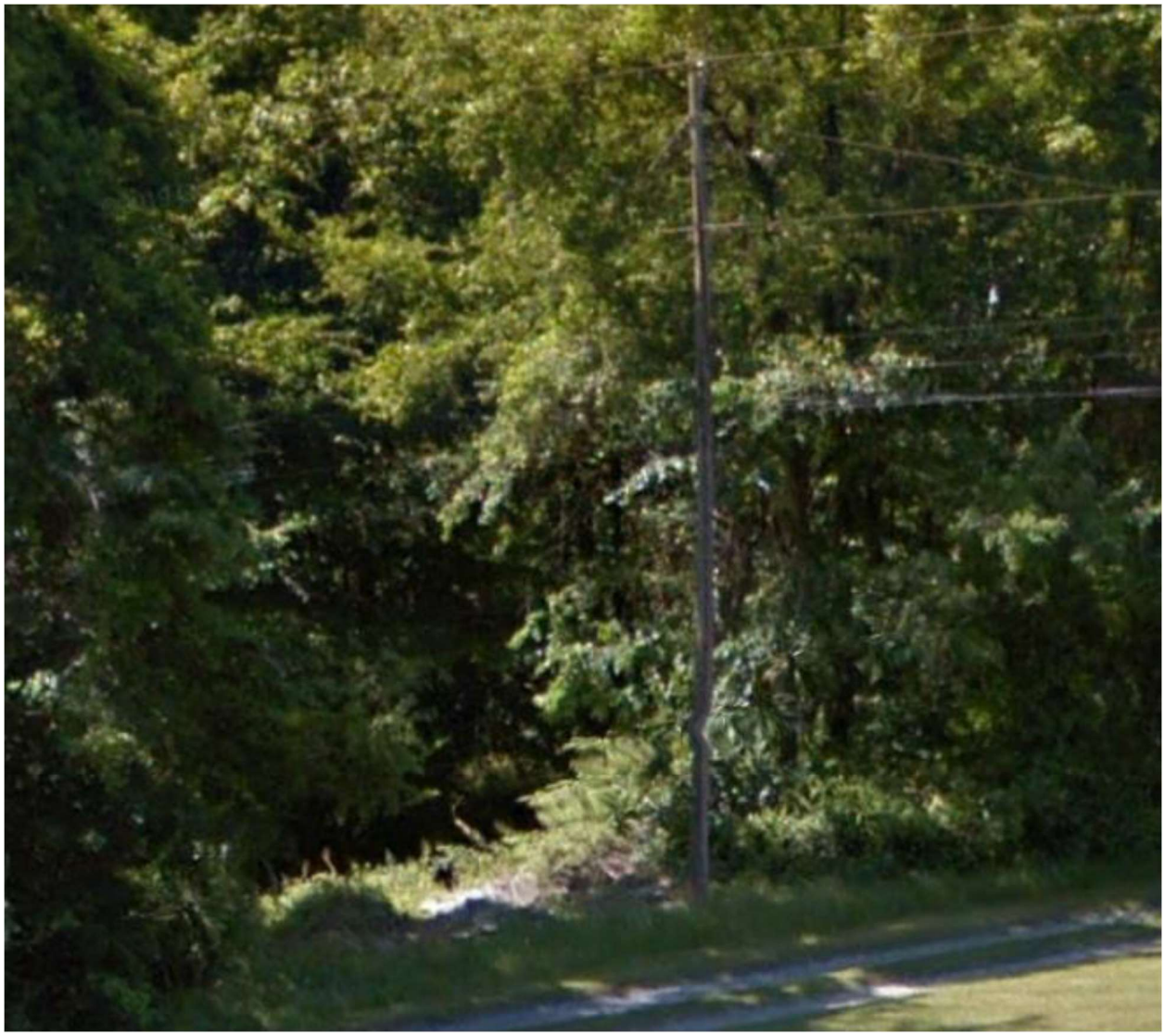


Figure 14 shows a pole line that has only one existing attachment in the communications space on the power poles. Where make-ready is low, as in this case, the cost of aerial construction is less than in high make-ready areas.

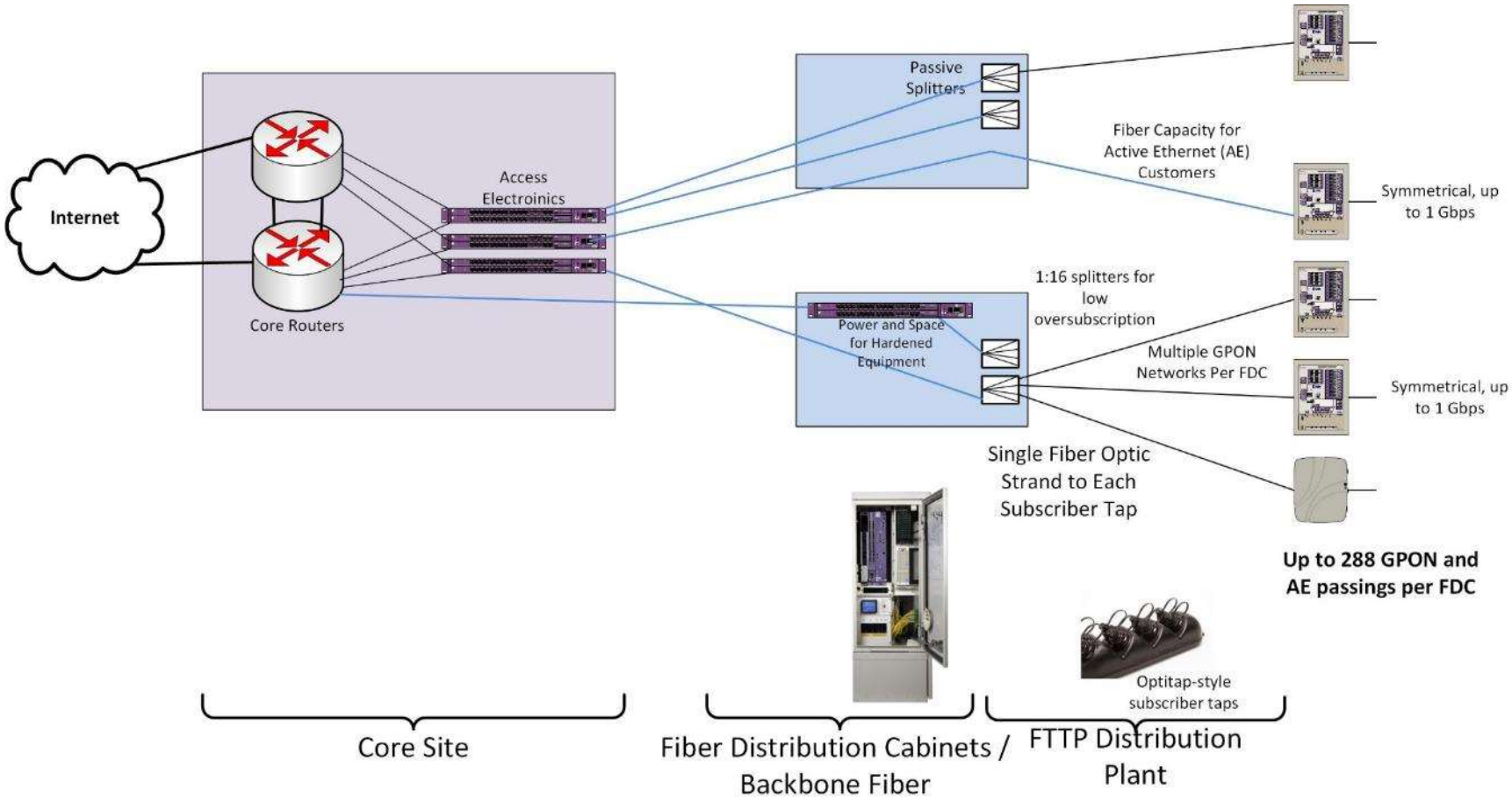
Figure 14: Low-Make-Ready Pole Line in Unserved Area

3.3 Network Architecture

We developed a conceptual, high-level fiber-to-the-premises outside plant network design that is aligned with best practices in the industry and is open to a variety of electronic architecture options.[25] Figure 15, below, shows a logical representation of the fiber-to-the-premises network architecture we recommend based on the conceptual outside plant design.

[25] The network's outside plant is both the most expensive and the longest-lasting portion. The architecture of the physical plant determines the network's scalability for future uses and how the plant will need to be operated and maintained; the architecture is also the main determinant of the total cost of the deployment.

Figure 15: High-Level Fiber-to-the-Premises Architecture



This drawing illustrates the primary functional components in the fiber-to-the-premises network, their relative position to one another, and the flexibility of the architecture to support multiple subscriber models and classes of service.

The recommended architecture is a hierarchical data network that provides scalability and flexibility, both in terms of initial network deployment and its ability to accommodate the increased demands of future applications and technologies without requiring expensive new construction. The characteristics of this hierarchical fiber-to-the-premises data network are:

- **Capacity** – ability to provide efficient transport for subscriber data, even at peak levels
- **Availability** – high levels of redundancy, reliability, and resiliency; ability to quickly detect faults and re-route traffic
- **Failsafe operation** – physical path diversity in the network backbone to minimize operational impact resulting from fiber or equipment failure
- **Efficiency** – no traffic bottlenecks; efficient use of resources
- **Scalability** – ability to grow in terms of physical service area and increased data capacity, and to integrate newer technologies without new construction
- **Manageability** – simplified provisioning and management of subscribers and services
- **Flexibility** – ability to provide different levels and classes of service to different customer environments; can support an open access network or a single-provider network; can provide separation between service providers on the physical layer (separate fibers) or logical layer (separate Virtual Local Area Network (VLAN) or Virtual Private Network (VPN) providing networks within the network)
- **Security** – controlled physical access to all equipment and facilities, plus network access control to devices

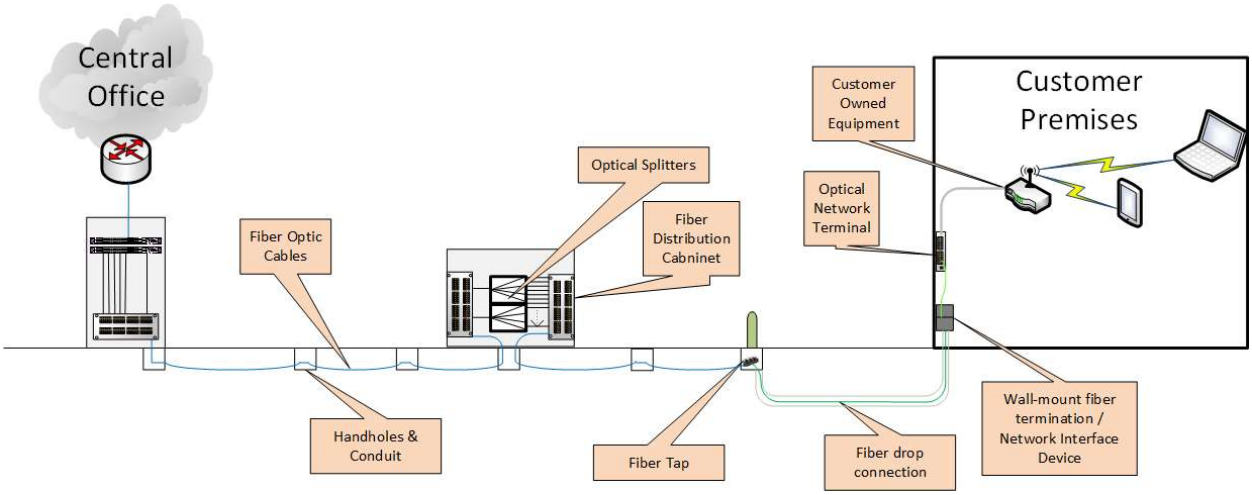
This architecture offers scalability to meet long-term needs. It is consistent with best practices for either a standard or an open-access network model to provide customers with the option of multiple network service providers. This design would support the current industry standard gigabit passive optical network technology. It could also provide the option of direct Active Ethernet services.[26]

[26] The architecture enables the network to provide direct unshared Active Ethernet connections to 5 percent of customers, which is appropriate for a select group of high-security or high capacity commercial users (e.g., banks,

The design is based on a Gigabit Passive Optical Network (GPON) architecture, which is the most commonly provisioned FTTP service—used, for example, by AT&T Fiber, Verizon (in its FiOS systems), Google Fiber, and Sonic.net. GPON supports high-speed broadband data, and is easily leveraged by triple-play carriers for voice, video, and data services.

GPON uses passive optical splitting, which is performed inside fiber distribution cabinets (FDC), to connect fiber from the Optical Line Terminals (OLTs) to the customer premises where it connects to an Optical Node Terminal (ONT) on the outside or inside of the premise. With GPON service, the FDCs house multiple optical splitters, each of which splits the fiber link to the OLT between 16 to 32 customers. The GPON OLT uses single-fiber (bi-directional) modules called SFPs (Small Form Factor Pluggable) which consists of a laser transmitter and a receiver to support multiple (most commonly less than 32) subscribers, so each customer receives a fiber connection all the way to the premise.

Figure 16 - GPON Fiber Network with a Buried Service Drop



The chief advantage of this type of architecture lies in the simple architecture and passive design which makes installation straightforward, and is very cost effective to operate, with few active pieces that can break. Even though the GPON platform is limited to 1.2 Gbps upstream and 2.4 Gbps downstream for the subscribers connected to a single PON (meaning the bandwidth available to the individual subscriber needs to be divided with others on the PON), operators have found that the variations in actual subscriber usage generally means that all subscribers can obtain 1 Gbps on demand (without provisioned rate-limiting), even if the capacity is aggregated at the PON. The platform has also proven to be versatile: many GPON manufacturers have developed technology to support up to 10 Gbps and faster speeds as user demand increases, and

wireless small cell facilities). In extreme cases, the network can provide more customers with Active Ethernet with the addition of electronics at the fiber distribution cabinets on an as-needed basis.

these are already implemented by many providers delivering business services.[27] In fact, part of the attraction of GPON technology is that much of the infrastructure can be upgraded in a relatively easy and cost effective manner. Some OLTs already support the next generation PON technologies (such as XGS-PON and NGPON2), so much of the GPON investment can be reused, and upgrades can be done incrementally as needed.

The design assumes placement of manufacturer-terminated fiber tap enclosures within the public right-of-way or easements, providing watertight fiber connectors for customer service drop cables, and eliminating the need for service installers to perform splices in the field. This is an industry-standard approach to reducing both customer activation times and the potential for damage to distribution cables and splices. The model also assumes that the County or a partner obtains easements or access rights to private drives to access homes as needed.

3.4 Required Fiber Backbone

We used the following unit cost assumptions when developing our estimated fiber construction costs (Table 4). Cost estimates are based on other, similar fiber-to-the-premises projects.

Table 4: Unit Cost Estimate Assumptions

Description	Unit	Assumption
Placement of 2-inch conduit using directional boring	$/foot	$12.50
Pull-box placement, 24"x36"x36" Tier 22	each	$1,050
Aerial cable installation per foot	$/foot	$1.50
Traffic control and work area protection per foot	$/foot	$.25
Tree trimming	$/foot	$.25
Make-ready per foot	$/foot	$0.32
288-count cable	$/foot	$2.05
Aerial fiber installation materials	$/foot	$1.30

The network design (see conceptual map below) and cost estimates assume the County or a partner will:

- Place a new core facility (if needed) on existing County land or right-of-way. The cost estimate includes the facility costs with adequate environmental and backup power generators to house network electronics and provide backhaul to the internet.[28]

[27] Verizon, for example, is rolling out NGPON2 supporting 5G, as well as FiOS and business services. See https://www.lightwaveonline.com/fttx/pon-systems/article/14034625/verizon-full-speed-ahead-with-ngpon2-for-5g-mobile-support

[28] Any additional equipment, power, and backup will be on the provider. Existing providers, incumbents or non-incumbents, typically will not need any additional facilities, power, and backup generators from what they already have.

- Construct 75 miles of backbone network[29] to connect the unserved communities to the core via 14 fiber distribution cabinets. The fiber distribution cabinets will be located in the public right-of-way or on County-owned land that provides adequate space for the hosting and maintenance of the cabinet.

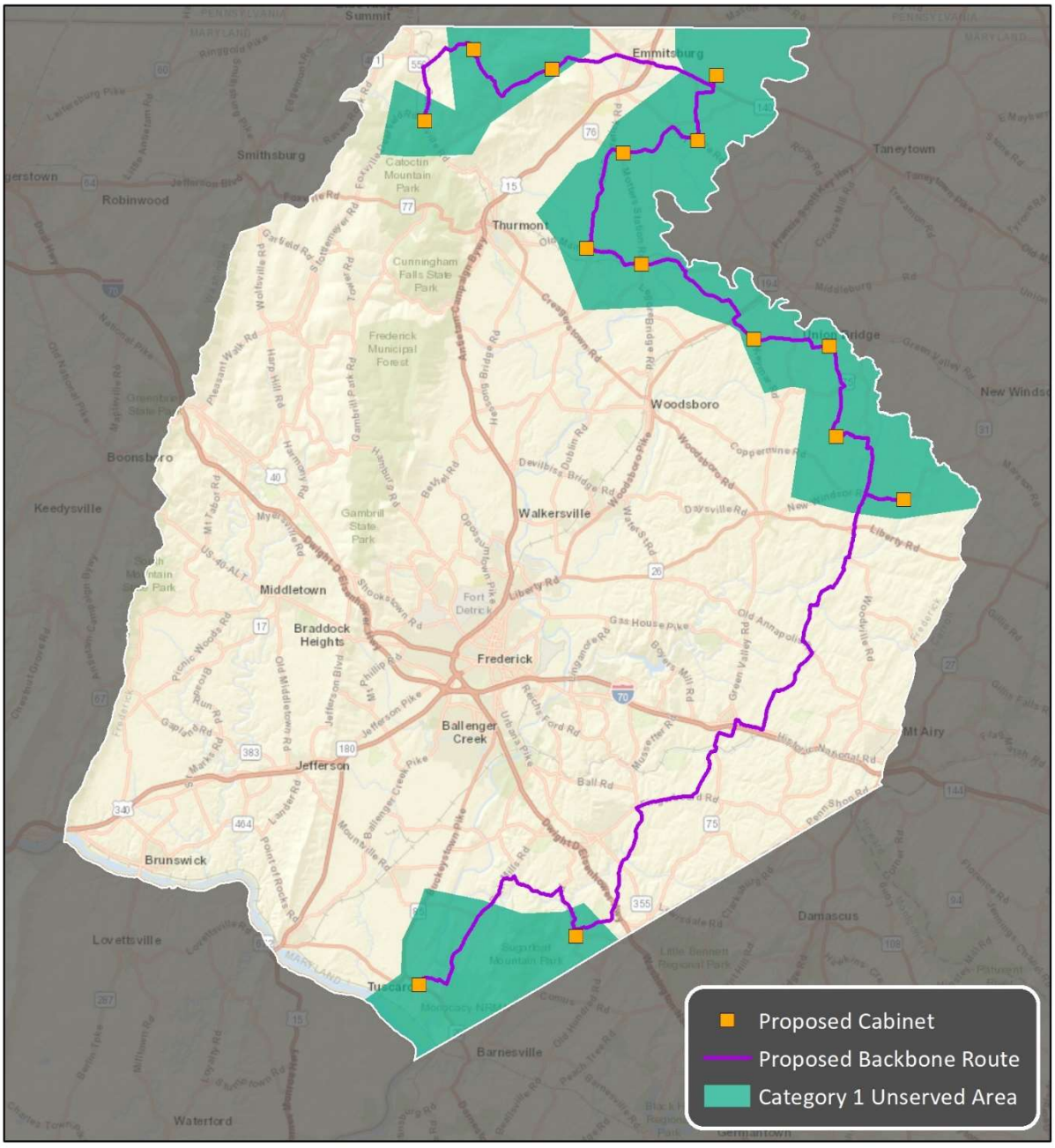
- Construct 253 miles of fiber optics[30] from the fiber distribution cabinets to 3,200 homes and businesses (i.e., from termination panels in the fiber distribution cabinet to tap locations in the public right-of-way or on easements near the home or business).

- Obtain easements or access rights to private roads where public rights-of-way do not exist.

A new core site would not be needed for most operators who will backhaul to their existing network where they already have core equipment or—as in the case of incumbents such as Comcast—will simply extend the footprint of their existing architecture, including core sites. Should a new core facility be necessary, and County land not be available, the provider will typically pick an affordable location that makes sense for its own particular hub design (and that has access to power). Depending on it needs, the provider may locate close to other providers to secure additional backhaul or cross-connects with those providers. The size requirements for such a site are modest and could be as small as a traffic-signal enclosure.

[29] The backbone construction costs are included in the cost of the fiber-to-the-premises network.
[30] These are GIS calculated on actual distances of roads from distribution points based on the sample design. That would mean about 12.5 premises per mile.

Figure 17: Conceptual Fiberoptic Backbone Design



The fiber-to-the-premises network design was developed with the following criteria based on the above assumptions and required characteristics of the hierarchical fiber-to-the-premises network:

- Fiber will vary between 12- and 288-count based on the projected need in the area.

- Fiber will be installed in the communications space of the electric utility poles where poles are present, and in newly constructed underground conduit in other areas.
- Fiber will be installed in the public right-of-way or in an easement on the side of the road.
- The network will target up to 288 passings per fiber distribution cabinet.
- Fiber distribution cabinets will support hardened network electronics and provide backup power and an active heat exchange.[31]
- The network routes will avoid the need for distribution plant to cross major roadways and railways.

As with any utility, the design and associated costs for construction vary with the unique physical layout of the service area—no two streets are likely to have the exact same configuration of fiber optic cables, communications conduit, underground vaults, and utility pole attachments. Costs also vary by soil conditions, such as the prevalence of subsurface rock; the condition of utility poles and feasibility of aerial construction involving the attachment of fiber infrastructure to utility poles; and crossings of bridges, railways, and highways.

A key point to understand is that aerial construction (i.e., attaching fiber infrastructure to existing utility poles) could offer significant savings compared to all-underground construction but increases uncertainty around cost and timeline. Under some circumstances, costs related to pole remediation and make-ready construction can make aerial construction cost-prohibitive in comparison to underground construction. However, as discussed in Section 3.2, our desk survey found that the majority of poles likely have sufficient space and capacity, and that the amount of needed make-ready is mostly average.

We assume the fiber will be strand-mounted in the communications space on the existing utility poles. Splice cases, subscriber taps, and drops will also be attached to the strand, which will facilitate maintenance and customer installation.

While generally allowing for greater control over timelines and more predictable costs, underground construction is subject to uncertainty related to congestion of utilities in the public right-of-way—which cannot be fully mitigated without physical excavation and/or testing. In the

[31] These hardened fiber distribution cabinets reflect an assumption that the network's operational and business model will require the installation of provider electronics in the fiber distribution cabinets that are capable of supporting open access among multiple providers. We note that the overall fiber-to-the-premises cost estimate would decrease if the hardened fiber distribution cabinets were replaced with passive fiber distribution cabinets (which would house only optical splitters) and the providers' electronics were housed only at the hub facility.

County, however, congestion of utilities appears to be reasonable for most areas, which makes underground construction more viable than is typically the case.

While anomalies and unique challenges will arise regardless of the design or construction methodology, the relatively large scale of this project is likely to provide ample opportunity for variations in construction difficulty to yield relatively predictable results on average.

We assume underground construction will be done using an industry-standard approach for this type of environment, which consists primarily of horizontal, directional drilling to minimize public right-of-way impact and to provide greater flexibility to navigate around other utilities. The design model assumes a single 2-inch, flexible, high-density polyethylene (HDPE) conduit over underground distribution paths, and dual 2-inch conduits over underground backbone paths to provide scalability for future network growth.

Costs for aerial and underground placement were estimated using available unit cost data for materials and estimates on the labor costs for placing, pulling, and boring fiber based on construction in comparable markets. The material costs were known, with the exception of unknown economies of scale and inflation rates and barring any shortages or supply disruptions restricting material availability and increasing costs. The labor costs associated with the placement of fiber were estimated based on comparable construction projects.

3.5 Fiber-to-the-Premises Cost Components

3.5.1 Outside Plant Cost Components

The cost components for outside plant construction include the following tasks:

- ***Engineering*** – includes system-level architecture planning, preliminary designs, and field walk-outs to determine candidate fiber routing; development of detailed engineering prints and preparation of permit applications; and post-construction "as-built" revisions to engineering design materials
- ***Quality Control / Quality Assurance*** – includes expert quality assurance field review of final construction for acceptance
- ***General Outside Plant Construction*** – consists of all labor and materials related to "typical" underground or aerial outside plant construction, including conduit placement, utility pole make-ready construction, aerial strand installation, fiber installation, and surface restoration; includes all work area protection and traffic control measures inherent to all roadway construction activities

- ***Special Crossings*** – consists of specialized engineering, permitting, and incremental construction (material and labor) costs associated with crossings of railroads, bridges, and interstate / controlled access highways
- ***Backbone and Distribution Plant Splicing*** – includes all labor related to fiber splicing of outdoor fiber optic cables
- ***Backbone Hub, Termination, and Testing*** – consists of the material and labor costs of placing hub shelters and enclosures, terminating backbone fiber cables within the hubs, and testing backbone cables

The assumptions, sample designs, and cost estimates were used to extrapolate an outside plant infrastructure cost of $66,000 per mile.

The distribution plant covers 253 miles, leading to a total outside plant cost of approximately $16.8 million. This leads to an average outside plant cost per passing of approximately $5,250. Table 5 provides a breakdown of the estimated outside plant costs.

Table 5: Estimated Outside Plant Costs[32]

Cost Per Plant Mile[33]	Distribution Plant Mileage	Total Cost	Estimated Passings	Cost per Passing[34]
$66,000	253	$16.8 million	3,200	$5,250

The actual cost to construct fiber-to-the-premises to every unserved Category 1 premises in the County could differ from the estimate due to changes in the assumptions underlying the model. For example, if make-ready and pole replacement costs are too high, the network would have to be constructed underground—which could significantly increase the cost of construction. A non-uniform take-rate (i.e., the percentage of passed customers that choose to purchase a service) across different areas could also influence costs. A lower take-rate would not substantially affect outside plant and core equipment costs; it would only reduce the costs for drops and customer premises equipment.

[32] Unrounded numbers are used in the engineering calculations; these are then rounded in the table and the discussion.
[33] The cost per plant mile is the average cost of constructing a mile of outside plant for the fiber-to-the-premises network.
[34] The cost per passing is the average cost to construct the outside plant for the fiber-to-the-premises network to pass each premises within the unserved areas.

Our estimated take rate of 60 percent is consistent with networks in similar markets and on the conservative end. Take-rates vary with a variety of factors: price points for services, the quality of customer service provided, and "level of desperation" for reliable broadband. The presence of an existing provider in the market—such as a fixed wireless service—could reduce take-rates because some subscribers will be happy with "good-enough" service. But if an existing low-speed internet provider underperforms or has pricing similar to the fiber-to-the-premises offering, then the fiber-to-the-premises operator could expect higher take-rates.

Further and more extensive analysis would be required to develop a more accurate cost estimate across the entire County.

Actual costs will also vary from this estimate due to factors that cannot be precisely known until the detailed design is completed, or until construction commences. These factors include costs of private easements; utility pole replacement and make-ready costs; variations in labor and material costs; and the County or its partner's operational and business model. We have incorporated suitable assumptions to address these items based on our experience in similar markets.

3.5.2 Central Network Electronics Costs

Central network electronics equipment to serve the unserved area will cost an estimated $800,000, assuming a 60 percent take-rate.[35] (These costs may increase or decrease depending on take-rate, and the costs may be phased in as subscribers are added to the network.) The network electronics consist of the core and distribution electronics to connect subscribers to the fiber-to-the-premises network at the core and the fiber-to-the-premises access electronics located at the fiber distribution cabinets. Table 6 lists the estimated costs for each segment.

Table 6: Estimated Central Network Electronics Costs

Network Segment	Subtotal
Core and Distribution Electronics	$500,000
Fiber-to-the-Premises Access Electronics	$300,000
Total	*$800,000*

The electronics are subject to a seven- to 10-year replacement cycle, as compared to the 20- to 30-year lifespan of a fiber investment.

[35] The take-rate affects the electronics and drop costs, but also may affect other parts of the network, as the County or its partner may make different design choices based on the expected take-rate. A 60 percent take-rate is possible in environments where a new provider delivers service in a previously unserved area. Market research would be required to estimate a more accurate take-rate at assumed service costs.

3.5.2.1 Core and Distribution Electronics

The core electronics connect the network to the internet. The core electronics consist of high-performance routers, which handle all the routing on both the network and to the internet. The core routers have modular chassis to provide high availability in terms of redundant components and the ability to "hot swap" line cards in the event of an outage.[36] Modular routers also provide the ability to expand the routers as demand for additional bandwidth increases.

The cost estimate design envisions running networking protocols, such as hot standby routing protocol, to ensure redundancy in the event of a router failure. Additional connections can be added as network bandwidth increases. The core sites would also tie to the distribution electronics using 10 Gbps links. The links to the distribution electronics can also be increased with additional 10 Gbps and 40 Gbps line cards and optics as demand grows on the network. The core networks will also have 10 Gbps to ISPs that connect the network to the internet.

We estimate the cost of the core routing equipment to be approximately $500,000.[37] In addition, the network requires operations support systems, such as provisioning platforms, fault and performance management systems, remote access, and other operational support systems for operations. For a network of this scale, an operations support system costs approximately $100,000 to acquire and configure. (We have not included that cost in the totals above because the system might be the responsibility of the County's partner.)

3.5.2.2 Fiber-to-the-Premises Access Electronics

The access network electronics at the fiber distribution cabinets connect the subscribers to the network by connecting the backbone to the fiber that goes to each premises. These electronics are commonly referred to as optical line terminals. We recommend deploying access network electronics that can support both gigabit passive optical network and Active Ethernet subscribers to provide flexibility within the fiber distribution cabinet service area. We also recommend deploying modular access network electronics for reliability and the ability to add line cards as more subscribers join in the service area. Modularity also helps reduce initial capital costs.

The cost of the access network electronics for the network is estimated at approximately $300,000. These costs are based on a take-rate of 60 percent and include optical splitters at the fiber distribution cabinets aligned to that take-rate. An alternative design places the optical line terminals at the core location, with the fiber distribution cabinets containing only splitters. As

[36] A "hot swappable" line card can be removed and reinserted without the entire device being powered down or rebooted. The control cards in the router should maintain all configurations and push them to a replaced line card without the need for reconfirmation.

[37] The purpose of this study is to understand very rough estimated that allows for a strategic analysis and gives County decision makers an understanding of the scope of the problem. For high level cost estimates, we use a multiplier based on passings for core equipment needs generated from previous studies and cost estimates.

the County or its partner examines more closely the specific electronics architecture, this alternative may be a suitable approach—and would reduce the size of the fiber distribution cabinets and provide a small cost savings.

3.5.3 Per-Subscriber Costs)

Each activated subscriber would also require a fiber drop cable installation and related customer premises equipment, which would cost on average roughly $1,500 per subscriber, or $2.9 million total—again, assuming a 60 percent take-rate.

Customer premises equipment is the subscriber's interface to the network; for gigabit passive optical networks, these electronics are referred to as an optical node terminal. For this cost estimate, we selected customer premises equipment that both terminates the fiber from the network and provides only Ethernet data services at the premises (however, there are a wide variety of additional customer premises equipment offering other data, voice, and video services). The customer premises equipment can also be provisioned with wireless capabilities to connect devices within the customer's premises. Using the assumed take-rate of 60 percent, we estimated the cost for subscriber customer premises equipment and installation to be $500 per subscriber, or approximately $1.0 million systemwide.

The drop installation cost is the biggest variable in the total cost of adding a subscriber. A short aerial drop can cost as little as $250 to install, whereas a long underground drop installation can cost upward of $5,000. Based on the prevalence of aerial and underground utilities, and sample designs, we estimate an average of approximately $1,000 per drop installation (or approximately $1.9 million systemwide, assuming a 60 percent take-rate). The drop installation follows the existing utilities, so that if the existing utilities in the public right-of-way are aerial, the drop would be installed aerially and vice versa for underground. Average drop distances are extrapolated from sample designs developed for similar rural fiber-to-the-premises projects. Actual drop costs will vary for each premises.

The numbers provided in Table 7, below, are averages and will vary depending on the type of premises and the internal wiring available at each premises.

Table 7: Per-Subscriber Cost Estimates

Construction and Electronics Required to Activate a Subscriber	Estimated Average Cost
Drop Installation and Materials	$1,000
Subscriber Electronics (Optical Node Terminal)	$200
Electronics Installation	$200
Installation	$100
Total	*$1,500*

3.6 Annual Fiber-to-the-Premises Operating Costs

Some of the ongoing costs of operating a fiber-to-the-premises network include fiber maintenance, fiber locating, pole attachment fees, and equipment replacement (Table 8). These estimates include costs directly related to the maintenance and operations of the physical and network electronics layers of the network, but does not include costs associated with higher layer services and other fixed administrative expenses that would otherwise be incurred regardless of the technical approach to network transport.

Regular fiber maintenance includes any add, moves, and changes required of the network. For example, if a roadway is widened a pole line may be moved or undergrounded, requiring the County to relocate this fiber. We estimate that 1 percent of the total capital costs, or $170,000, is required annually for fiber maintenance.

Fiber locating includes the marking of underground utilities as part of the state's Miss Utility process. Each underground utility is responsible for locating and marking its infrastructure in the right-of-way. We estimate the cost at $1,800 per mile of underground construction annually for utility locates, or $30,000 annually for the estimated 13 miles of underground plant (i.e., 5 percent of the 253 miles of distribution fiber).

For every pole to which the fiber network attaches, the County or its partner must pay the pole owner an attachment fee for maintenance of the utility pole line. We estimate a pole attachment fee of $20 per pole per year or a total of approximately $110,000 annually for approximately 240 miles of aerial plant i.e., 95 percent of the 253 miles of distribution fiber). Pole attachment fees are estimated and would be negotiated with the pole owners as part of the pole attachment process.

We also recommend establishing an equipment replacement fund, into which the County or its partner would put a portion of the necessary funds to replace the network electronics. We recommend planning on replacing the network electronics every seven years, requiring the County or its partner to place approximately $115,000 into the equipment fund annually.

Table 8: Estimated Annual Fiber-to-the-Premises Technical Operating Costs

Description	Annual Cost
Fiber Maintenance	$170,000
Fiber Locating	$30,000
Pole Attachment Fees	$110,000
Equipment Replacement Fund	$115,000
Total	*$425,000*

4 A Fixed-Wireless Solution to Address One-Third of Category 1 Properties

4.1 Overview

CTC's analysis found that fixed wireless technologies and infrastructure could be used to deliver broadband access to only about one-third of the approximately 3,000 addresses within the identified Category 1 unserved areas in Frederick County.

Our analysis found that, although it would have clear technical limitations relative to a fiber optic network, a fixed wireless network could cover more than 1,150 of the County's unserved addresses (or approximately 35 percent of the homes in the unserved areas) at an estimated cost of $2.6 million. The network would leverage eight existing telecommunications towers. It would use point-to-point wireless technology for backhaul connections.

Table 9 summarizes the costs and coverage of the candidate network.

Table 9: Fixed Wireless Analysis Results

Number of Towers	Addresses Served	Addresses Served per Tower	Cumulative Percent Served	Capital Cost	Average Distribution Network Cost per Passing	Installation and CPE Cost per Customer
8	1,156	145	36.2	$2,600,000	$ 1,200	$1,800

Note: Capital cost assumes a 60 percent take-rate.

Although fixed wireless technology has technological limitations relative to a fiber optic service (as well as higher operational costs and a shorter technology lifetime), wireless technology has benefits in terms of lower capital costs and reduced time to deploy. Furthermore, as discussed below, new developments in wireless technology are improving the reliability and speed of wireless broadband, and therefore these technologies are a better option now than they were in the recent past.

The following sections:

- Provide a high-level introduction to fixed wireless connectivity (including technologies, basic architecture, spectrum, and elements of costs)
- Describe the use of existing and new structures to deploy a fixed wireless solution for the County's unserved homes and businesses

4.2 Introduction to Fixed Wireless Technology

Broadband speeds in compliance with the FCC's definition (i.e., 25 Mbps download, 3 Mbps upload—which is also the definition of "served" approved by the County for this project) are more readily available from fixed wireless networks than in the past, owing to the recent introduction of the Citizens Broadband Radio Service (CBRS) spectrum into the market and new wireless technologies. While wireless internet service providers (WISP) typically are not able to offer connection speeds on a market-wide basis comparable to cable or fiber networks built to each premises, a fixed wireless connection may be a desirable solution if cable or fiber is not cost-effective. This is especially true in low-density rural areas where there are few homes and businesses per mile, and therefore the cost of building wired networks is often high.

As opposed to an underground or aerial cable, wireless broadband is delivered via access point antennas mounted on towers or rooftops. Customers' antennas may be mounted on a building (i.e., the home or business) or on a mast on a customer's premises (Figure 18).

Figure 18: Sample Fixed Wireless Network with Various Customer Antenna Configurations

4.2.1 Fixed Wireless Spectrum and Architecture

Fixed wireless networks typically use the following spectrum:

- TV White Space (TVWS) 500 MHz
- Unlicensed 900 MHz, 2.4 GHz, 5 GHz
- Citizens Broadband Radio Service (CBRS) 3.5 GHz

It is useful to determine which band may be most effective to use in different areas. Each band will need its own set of equipment; if one or more band can be eliminated from specific sites, then the overall cost of deployment and operations will be reduced.

Of these bands, only CBRS and 5 GHz unlicensed technology have channel widths capable of delivering 25 Mbps down and 3 Mbps up—so those are the two primary bands we considered. The CBRS band is predicted to connect the most addresses. (In addition to the spectrum properties, the ability to connect is due to the antennas being allowed to be mounted higher than the TVWS antennas under the licensing rules of the FCC, and CBRS being allowed to have the greatest broadcast power of the three technologies.)

That said, we also considered TVWS—which delivers service over unused television frequencies (known as white space). TVWS bands have much better non-line-of-sight transmission qualities than the other bands; however, due to its narrower bandwidth, TVWS is not capable of delivering 25 Mbps down, and therefore should only be considered in cases where other connectivity is not available or feasible. Also, because white space technology is still in an early Scenario of development, compatible equipment is far more expensive than other off-the-shelf wireless equipment. Finally, because the County has many existing broadcast television channels, the potential TVWS spectrum may be limited.

Most fixed wireless network solutions require the antenna at the subscriber location to be in or near the line of sight of the base station antenna. This can be especially challenging in mountainous regions. It is also a problem in areas with dense vegetation or multiple tall buildings. WISPs often need to lease space at or near the tops of radio towers; even then, some customers may be unreachable without the use of additional repeaters. And because the signal is being sent through the air, climate conditions like rain and fog can impact the quality of service. In our Scenario, we assumed that the tops of any existing towers are already utilized, and that any new equipment would be placed at 80 percent of the current tower height.

In addition, there is a tradeoff in these bands between capacity and the ability to penetrate obstructions such as foliage and terrain. The higher frequencies have wider channels and therefore the capability to provide the highest capacity. However, the highest frequencies are those most easily blocked by obstructions.

Wireless equipment vendors offer a variety of point-to-multipoint and point-to-point solutions. The Scenarios in this document assume point-to-multipoint equipment, which is typical for a residential or small business connection. Point-to-point service would typically be chosen by a medium-sized business, because it would enable dedicated bandwidth (at a higher cost than a point-to-multipoint service); that said, point-to-point networks may have limited network capacity, particularly in the upstream, making the service inadequate for applications that require high-bandwidth connections.

4.2.2 Fixed Wireless Deployment Costs

The following factors will determine the costs associated with a fixed wireless network:

- **Wireless equipment used:** Different wireless equipment has different aggregate bandwidth capacity and uses a range of different spectrum bands, each with its own unique transmission capabilities

- **Backhaul connection**: Although the bottleneck tends to be in the last-mile connection, if a WISP cannot get an adequate connection back to the internet from its tower, equipment upgrades will not be able to increase available speeds beyond a certain point

- **Future capacity and lifespan of investment:** Wireless equipment generally requires replacement every five to 10 years, both because exposure to the elements causes deterioration, and because the technology continues to advance at a rapid pace, making decade-old equipment mostly obsolete; the cost of deploying a wireless network is generally much lower than deploying a wireline network, but the wireless network will require more regular investment.[38]

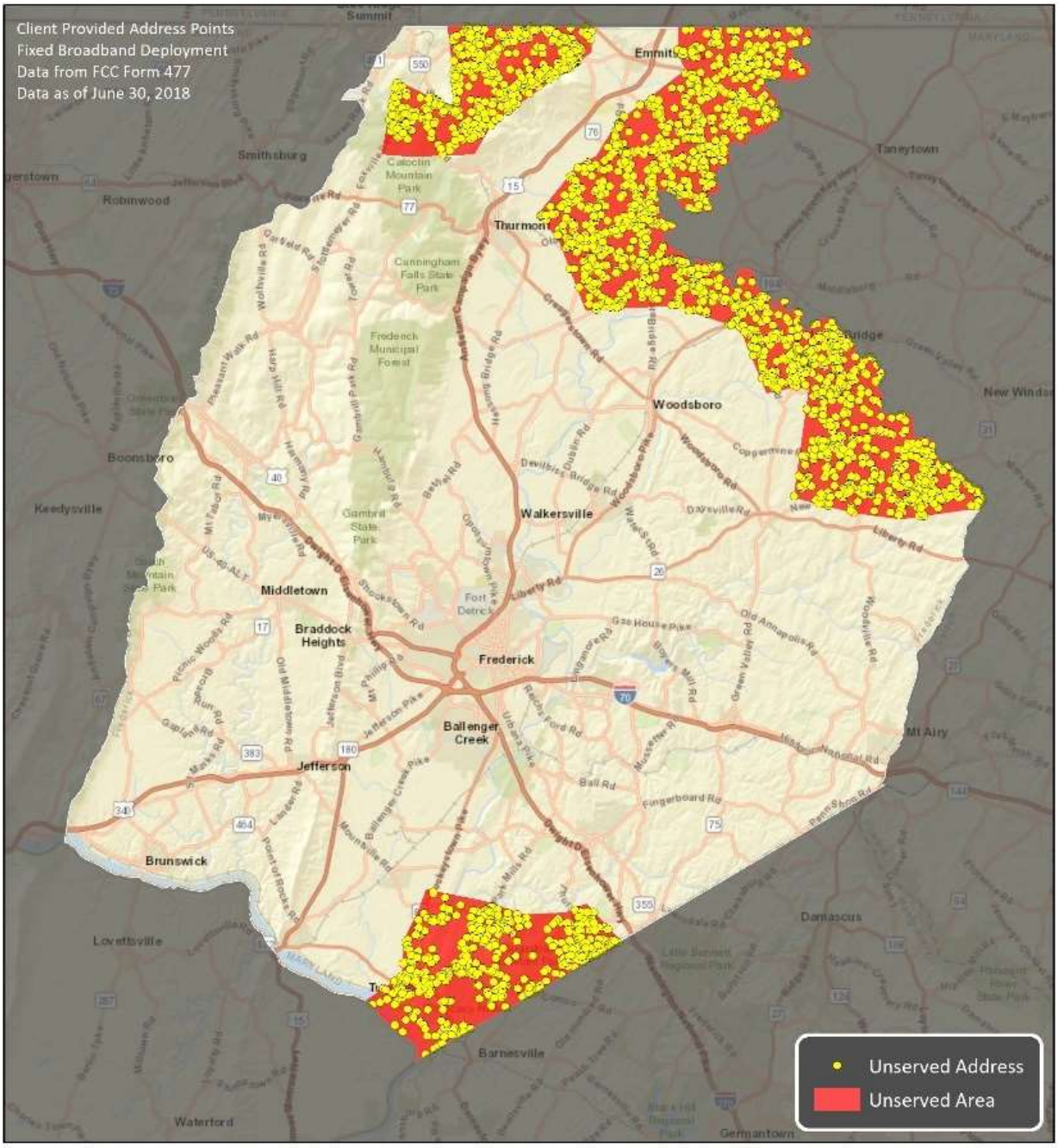
- **Availability of unobstructed line of sight:** Most wireless networking equipment requires a clear, or nearly clear, line of sight between antennas for optimum performance; WISPs often lease space near the tops of radio towers, to cover the maximum number of premises with each base station

4.3 Radio Frequency Coverage Analysis

We conducted a wireless analysis to determine how the County's unserved addresses (Figure 19) could be served via fixed wireless. The high-level scenario is for planning purposes only.

[38] That effectively means replacing the entire asset infrastructure (unless wireless operators construct their own towers). Upgrade in equipment can also mean relocation to a different tower, or different height on the same tower, and change in frequencies and licensing.

Figure 19: Unserved Areas and Addresses in Frederick County



The radio frequency (RF) coverage analysis was modelled using CloudRF, which is an online service available for modelling RF propagations. The software was chosen because of its ability to output coverage maps in a GIS layer than can be overlaid on the unserved address points, and therefore identify which of the addresses would be covered by the candidate wireless network.

Widely used propagation scenarios used for RF analysis include line of sight (LOS), cost 231, Okumura Hata, and Longley-Rice (also called the Irregular Terrain Model, or ITM). For our analysis we used ITM, which is the most conservative and takes into consideration atmospheric conditions, ground elevation, the deployment environment, obstacles between the base and mobile stations, and ground clutter.

We generated coverage propagation maps, such that the signal levels would achieve a minimum throughout for each of the frequencies used. For the 5 GHz and CBRS frequencies, the coverage maps indicate the coverage area where throughputs of 25 Mbps download and 3 Mbps upload speeds could be achieved at the cell edge. Because TVWS will not achieve these throughputs, the coverage maps indicate areas where 10 Mbps download and 2 Mbps upload speed could be achieved.

4.4 Tower Selection Methodology

To examine the potential of antennas mounted on existing towers to provide service to the County's unserved addresses using CBRS, unlicensed 5 GHz, and TVWS, we analyzed multiple commercial and government databases and identified approximately 22 existing tower locations in the County. We examined their height and ownership relative to their potential use as part of a technical solution, then selected eight of these existing towers based on the number of addresses each could serve. (All towers that could cover fewer than five addresses were removed.)

CTC assessed the coverage provided by each of the selected tower sites using the three fixed wireless frequency band options (CBRS, 5 GHz, and TVWS) to determine how many of the unserved addresses would be within each spectrum band's predicted coverage area. We based our analysis on the following assumptions:

- Antennas on towers would be placed at 80 percent of the tower height for 5 GHz and CBRS, and at the maximum allowable height of 30 meters (98.4 feet) for TVWS
- Broadcast power would be at the FCC limit for all three bands
- Channel bandwidth would be 10 MHz for the CBRS band
- Subscriber equipment antennas would be placed at 4.57 meters (15 feet) above the ground
- Ground elevation and clutter resolution would be 30 meters (98.4 feet)

4.5 Cost Assumptions

Our cost analysis makes the following assumptions:

- All served addresses will require subscriber equipment installed (60 percent take-rate)
- Towers will be configured with three sectors for each frequency used
- All selected towers will have CBRS deployed
- 25 percent of the towers will also have 5 GHz deployed
- 25 percent of the towers will also have TVWS deployed
- Towers will be connected to backhaul using microwave links; 10 percent of the sites will require an additional hop
- Engineering and design costs include propagation studies, RF path analysis for point-to-point connections, structural analysis, construction plans, and permits
- Site acquisition costs include the preliminary equipment dimensioning, power needs, shelter requirements, RF suitability, escorts, and lease negotiations
- There is room within the shelter at the tower location for additional equipment
- The estimate includes $20,000 for core network equipment (and setup) to manage functions such as authentication, billing, security, and connection to the internet
- The costs outlined are capital costs only and do not include operational costs

4.6 High-Level Coverage and Cost Estimate

Of the 22 existing telecommunications towers presently in the County, eight were identified that could serve at least five addresses within the unserved areas.

Base stations and antennas deployed to those eight towers could deliver service to an estimated 36 percent of the County's unserved premises. The orange shading in Figure 20 depicts the predicted coverage areas. The red indicates the remaining unserved areas. The light green dots show the existing tower locations.

Figure 20: Fixed Wireless Network Coverage and Tower Locations

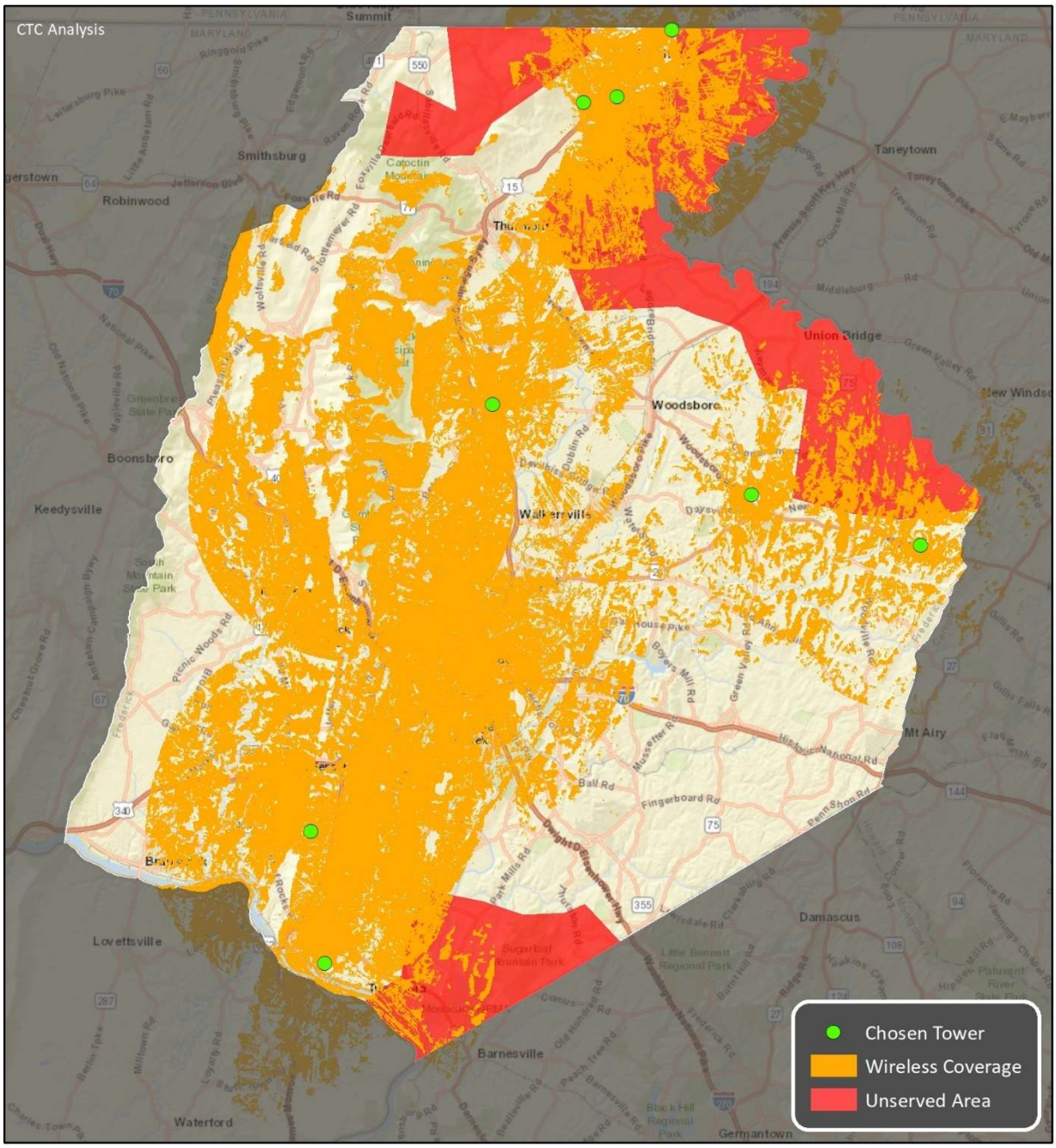


Table 10 indicates the penetration into the unserved addresses.

Table 10: Predicted Coverage of Candidate Fixed Wireless Solution

Addresses	Number
Total addresses in unserved area	3,194
Addresses covered	1,156
Addresses not covered	2038
Percent of addresses covered	36.2%

The cost breakdown for the candidate network is shown in Table 11 and Table 12.

Table 11: Capital Cost Estimate for Candidate Fixed Wireless Network

	Cost
Network Core	$200,000
Access Point Equipment	$135,000
Microwave Backhaul	$120,000
Installation, Engineering, and Design	$560,000
Site Acquisition	$320,000
Total Distribution Network Costs	$1,335,000
Total Addresses	1,156
Cost per Address (Distribution Network Only)	$1,200

Table 12: Total Cost Estimate for Candidate Fixed Wireless Network at Different Take-Rates

Item	Cost
Distribution Cost	$1,335,000
Total Cost (35% Take-Rate)	$2,100,000
Total Cost (60% Take-Rate)	$2,600,000
Distribution Cost per Address	$1,200
Average Cost per Customer (35% Take-Rate)	$5,100
Average Cost per Customer (60% Take-Rate)	$3,800

5 Comparison of Fiber-to-the-Premises and Fixed Wireless Solutions for Category 1 Areas

Overall, fiber-to-the-premises represents a better broadband solution than fixed wireless for most unserved areas of the County. Fiber-to-the-premises would be able to serve all of the County's Category 1 unserved homes and businesses, whereas fixed wireless could only serve 36 percent of those premises (with antennas mounted on existing towers). In general, the total cost of ownership for fiber-to-the-premises is also lower than for wireless networks over extended periods of time.[39]

A comparison of the two technologies must also recognize that fiber and fixed wireless each have technical advantages and challenges—and again, fiber-to-the-premises represents a better overall solution.

Fiber optics, once constructed, is the highest-speed and most scalable technology. Current off-the-shelf equipment enables fiber-to-the-premises networks to provide capacity in excess of 1 Gbps to each subscriber—and new electronics will enable those networks to go to 10 Gbps or beyond in the coming years. Moreover, fiber-to-the-premises networks are not subject to interference from other signals or subject to line-of sight limitations and could provide service to the County's entire Category 1 unserved area.

Over time, maintenance and repair costs of fiber optic cables are low—approximately 1 percent of construction costs annually. Equipment replacement occurs every seven years, but new equipment costs are only a percentage of the capital cost of a fiber-to-the-premises network.

As discussed in Section 3, however, fiber-to-the-premises construction costs can be high and can vary based on the availability of space on utility poles and in the right-of-way. Construction can be delayed by utility pole owners, other utilities on the poles, and the requirement for permitting in the right-of-way (including on bridges, water crossings, and expressway crossings).

By comparison to fiber-to-the-premises, fixed wireless technology provides an aggregate capacity between 100 Mbps and 250 Mbps. Using unlicensed and CBRS spectrum and innovations like higher-order multiple input, multiple output (MIMO) antennas and spatial multiplexing, these capacities could increase to as fast as 750 Mbps—lower than current fiber-to-the-premises capabilities. The lack of towers in the County's unserved area also limits the number of homes and businesses (36 percent) that can obtain service without constructing additional towers.

It is important to note, too, that this is the aggregate capacity of a single antenna or antenna array; in a point-to-multipoint architecture, this capacity will be shared among all users

[39] Total cost of ownership takes into account capital costs and maintenance costs—including tower lease fees and regular equipment replacement for wireless networks.

connected to a single base station. That said, in most of the unserved environments in the County, download speeds in the tens or even low hundreds of Mbps per user may be possible because of the low population density in those areas. Additionally, deploying fixed wireless rather than fiber-to-the-premises eliminates the need for new cable construction, significantly reducing the time to build and the complexity of construction.

Given the limitations of line of sight and of the available spectrum, however, the wireless solution is not as scalable as a wireline solution. The spectrum available for fixed wireless broadband is limited and provides much lower bandwidth than what is available in a fiber-to-the-premises network. Homes and businesses that have substantial tree cover and terrain will get poorer performance than others.

In addition, leasing space on a tower is costly. Leasing space for three sectors of antennas (as needed on each tower site in the candidate fixed wireless solution) costs approximately $60,000 per year. This is a critical consideration, because the fixed wireless model uses eight existing towers; with an average of about 145 serviceable passings (potential customers) per tower, the cost for tower leases alone exceeds $410 per year per passing.

Upgrading a wireless network requires replacement of the radios at the antenna site and at the user premises. Electronics may need to be replaced at five- to 10-year intervals due both to technological obsolescence and wear and tear. Unlike a fiber network, in which the most costly and valuable part of the network infrastructure is the fiber itself, the electronics comprise almost all of the capital cost of the fixed wireless network—so equipment replacement significantly increases the network's ongoing cost. In some cases, fixed wireless network replacement also entails migrating to new frequencies to seek higher bandwidths and less interference.

6 Federal and State Funding Opportunities

6.1 Overview of Funding Opportunities

Federal and state funding sources represent an important element of large-scale broadband deployments for unserved areas where no broadband is currently available. While these programs tend to have restrictions that affect their potential breadth of impact, our analysis is that the programs discussed below have the potential to assist the County's efforts to significantly reduce the number of unserved homes and businesses.

Determining which funding programs the County should target will depend on the identification of a willing partner, the County's ability and willingness to contribute capital to the effort, and the timing of the grants. That said, the state's grant program provides a very attractive funding options because the state is faithful to the federal 25/3 broadband definition of unserved, and does not have exclusions—meaning that the County could target some of the areas that are ineligible for federal grants.

The Rural Digital Opportunity Fund stands out with its massive budget and program design that favors fiber optic solutions. The FCC announced eligible areas that cover a large portion of the unserved areas in the County; while those eligible areas are subject to existing providers' challenges, the window for contesting eligibility has closed—and much of the County's unserved areas are likely to remain eligible.

There also is likely going to be infrastructure- or broadband-specific funding available through future Covid-19-related congressional appropriations. These could be funneled through existing federal grant programs (such as the U.S. Department of Commerce's Economic Development Administration's emergency grant programs), special new programs, or pass-through block grants to states. We do not know the extent to which such future grants will require private partners, public infrastructure, and/or matching funds, but the funds are likely going to be distributed and expected to be expended rapidly in order to have maximal and timely impact. The greater the extent to which the County can cultivate relationships to rapidly and creatively adapt partnership arrangements in target areas, the more likely the County will be able to take advantage of such opportunities.

6.2 State of Maryland Broadband Grants

The Governor's Office of Rural Broadband (the Office), which is housed in the Department of Housing and Community Development, focuses on efforts to extend broadband service to unserved rural parts of the state "through partnerships with local jurisdictions and the private

sector."[40] The Office currently oversees both a small pilot program and a larger rural broadband grant initiative that explicitly seeks to complement federal and local funding sources—an approach that would enable the County or a partner, if it receives one of those larger grant awards, to use the state's funding as a match for a potential federal ReConnect grant application (if the County determines that such an application would be feasible).

The unserved areas we described in Section 2 would be eligible for state funding—as would additional areas, because the state adopts the federal definition of broadband to delineate unserved areas. This is in contrast to federal grants which have exclusions, restrictions, and requirements that effectively shrinks the areas eligible for funding under its programs. Should the County be interested in pursuing a state grant, we recommend that it update the proposed funded service area (PFSA) maps to allow for the full unserved areas to be targeted.

The Office announced the details of its rural Broadband Infrastructure Network Buildout Program, with grants of $1 million to $3 million (with a total of at least $9 million in available funding program-wide), in late November 2019.[41] While the deadline for the first grants has passed, we expect several more phases—with largely the same requirements—beginning in the third or fourth quarter of 2020.

The applicant has to be a local jurisdiction or the jurisdiction's recognized partner. The grant will cover up to 50 percent of construction costs—with the applicant committing a 100 percent cash match—for a project that delivers at least 25/3 service to an unserved area.[42] Our sense is that these requirements intentionally put larger companies in a better position to apply because of their access to cash for the required match and ability to file for larger grants. The proposed service area does not have to be contiguous and can cross county boundaries.

Awardees will not be eligible for future grants from the program in the awarded jurisdiction for two years or until construction is complete, whichever is later.

The Office earlier solicited statements of interest from local jurisdictions for "Assistance for Broadband Expansion Pilot Projects." The state is expected to continue to award relatively small grants of up to $200,000 to local jurisdictions, in partnership with an ISP, to cover as much as "50

[40] "Maryland Rural Broadband," Maryland Department of Housing and Community Development, https://dhcd.maryland.gov/RuralBroadband/Pages/default.aspx (accessed December 2019).
[41] "Maryland Broadband Infrastructure Grant Program: Grant Application Guide," Governor's Office of Rural Broadband, State of Maryland, November 27, 2019, https://dhcd.maryland.gov/RuralBroadband/Documents/FY2020-Broadband-Infrastructure-Program-Grant-Application-Guide.pdf (accessed December 2019).
[42] The match must be in cash, not in-kind, and must be shown to be available at the time the grant contracts are executed. There is an exception to level of match requirements for Sustainable Communities (Maryland Department of Housing and Community Development) and Priority Funding Areas (Maryland Department of Planning).

percent of the construction costs related to an ISP extending service [from the ISP's existing network] to unserved households." The County and its partner would be required to commit a 100 percent match for the funding, and to delivering at least 25/3 service. We anticipate that this pilot project program will have a similar timeline to the network buildout program, with a slightly earlier deadline in the next phase of funding.

6.3 USDA's ReConnect Program

The USDA ReConnect program represented the most significant congressional appropriation of broadband funding since the Recovery Act in 2009—with $600 million allocated in 2019 and $550 million (with an added $100 million as part of the CARES Covid-19 response package) made available in 2020. The program awards loans, grants, or a combination of the two for last-mile connections in rural areas—with priority given to private-sector applications and public-private partnerships. It is overseen by the Rural Utilities Service (RUS). The most recent round of grant applications opened on January 31, 2020, and closed April 16, 2020. However, the program is well regarded in Congress and future rounds are considered likely.

Congress created a significant barrier to ReConnect funding for the County when it wrote the legislation: It made ineligible any areas for which another grantee or loan recipient has received a previous broadband award. This is not relevant for eligibility for any current funding opportunities for the County, since there are no areas for which federal funding was previously awarded in the County. But it is relevant for the County's consideration of appropriate partners for ReConnect applications: A fixed wireless provider receiving an award from this program would be protected from any other subsequent applicant for the entire originally funded service area for up to 10 years.

Our models for fixed wireless, however, have not found a way to serve all unserved premises in a claimed service area, and the County would therefore risk having no remedy for those unserved premises for the entire, long protection period. And, as discussed, the actual network performance within a fixed wireless service area varies widely from customer to customer. We therefore recommend the County prioritize applications to ReConnect for wireline solutions, or include robust remedies as conditions of support with the partner to manage risks.

The recent round of the ReConnect program comprised three separate funding categories: 100 percent grants (covering up to 75 percent of eligible project costs, with a 25 percent match), 50 percent grants with a 50 percent loan or other form of match, and 100 percent loans. Funds will go to rural areas where 90 percent or more of the households lack access to broadband speeds of at least 10 Mbps download and 1 Mbps upload. (In round one, 100 percent of the households in the PFSA had to lack access to 10/1 Mbps broadband for 100 percent grant awards.)

Applicants had to propose networks capable of providing access to every premises in the PFSA at minimum speeds of 25 Mbps downstream and 3 Mbps upstream.

Matching funds are a point of distinction. Awarded applicants for 100 percent grant awards will need to provide matching funds equivalent to 25 percent of the project's total cost—and that matching contribution must be expended first, followed by grant funds. For 50 percent grants with a 50 percent loan or other form of match, applicants could propose a cash alternative to the loan at the time of application. (For an awarded project in this scenario, all cash proposed must be expended first, followed by loan funds and then by grant funds.)

Generally, we anticipate that USDA will continue to prioritize private-sector applications and public-private partnerships, so it will be important for local governments to build a public-private partnership strategy for future rounds of this program. RUS will consider public networks that lack extensive experience to be startups and may disfavor their applications. Should the County decide to take the lead, it should partner only with entities with extensive experience as an ISP to compete for these funds. Any experienced ISP, whether public or private, will require the strong collaboration and support of its local (and state) government to present a compelling case for funding.

Applications to this program will require a detailed business plan and pro forma. RUS will grant application review points based on those plans, as well as many other factors. The rurality of the PFSA can earn almost 25 points alone. RUS will also award points to applications proposing to build networks capable of at least 100/100 Mbps. Additional points can be scored if the proposed area includes a healthcare center, education facility, or critical community facility. Furthermore, points will be awarded for projects in states with an updated broadband plan in the past five years.

We anticipate RUS will make grant/loan combinations in the $3 million to $10 million range. This is quite a bit more than RUS's Community Connect grants—and, because the program's funding is considerably larger in total dollars, we anticipate that ReConnect will make more awards. Further, ReConnect does not have the low-income requirements of Community Connect, making it a more flexible program.

6.4 FCC's Rural Digital Opportunity Fund

6.4.1 Latest Iteration

The Rural Digital Opportunity Fund represents the latest iteration of the FCC's Universal Service Fund's (USF) high cost program. Since 1996, the FCC has used the high cost program to subsidize telecommunications services in rural and remote areas, where the return on investment would otherwise be too low to prompt companies to invest in telecommunications infrastructure.

While the program initially provided subsidized telephone service on an ongoing basis, in 2011 the FCC began reorganizing the high cost program, creating the Connect America Fund (CAF) with the goal of accelerating the buildout of broadband-capable infrastructure to unserved and underserved areas. Instead of providing an ongoing subsidy in exchange for serving eligible areas, the CAF program provided an annual subsidy for a fixed period of time to help cover the initial cost of building out broadband-capable infrastructure in rural and remote areas.

The CAF program used a cost model to estimate the appropriate subsidy for each eligible census block, and first made these funds available to incumbent price-cap carriers in exchange for a commitment to serve every household and business with service with speeds of at least 10 Mbps download and 1 Mbps upload. For those areas where the price-cap carrier declined CAF support, the FCC made funds available to any qualifying service provider through a multi-round, reverse, descending clock auction, with added weight given to those bids that committed to offering faster and lower latency broadband services.

The CAF Phase II auction took place in 2018 and was widely viewed as a success. The auction awarded just under $1.5 billion in support in exchange for a commitment to serve 713,176 homes and small businesses in 45 states, a total of 73 percent of eligible areas. Thanks to the weighting system that favored service providers willing to offer higher tiers of service, 99.75 percent of locations will have speeds of at least 25/3 Mbps, 53 percent will have at least 100/20 Mbps, and 19 percent will have 1 Gbps/500 Mbps. The 103 winning bidders will receive an annual sum each year for 10 years, provided they meet buildout requirements. Winners must offer service to 40 percent of homes and businesses by year 3 and continue to increase by 20 percent each year until year 6 when 100 percent of eligible homes and businesses must be served.[43] The total amount of support awarded was 70 percent less than the Connect America Cost Model (CAM) estimated would be needed.[44] Although the reverse auction process was complex, it secured higher-quality service for consumers at a significantly lower cost to the Universal Service Fund than previous methods of allocating subsidies. The Rural Digital Opportunity Fund is an extension of and part of the FCC's CAF program. Whether future iterations of these auctions will be called CAF or Rural Digital Opportunity Fund is mostly a matter of branding.

6.4.2 Eligibility Analysis for Rural Digital Opportunity Fund Subsidies

The Rural Digital Opportunity Fund builds on the success of the CAF Phase II auction, and will allocate an additional $20.4 billion over the next decade in order to support the buildout of high-speed broadband networks in unserved areas of the country. The FCC announced that the $20.4

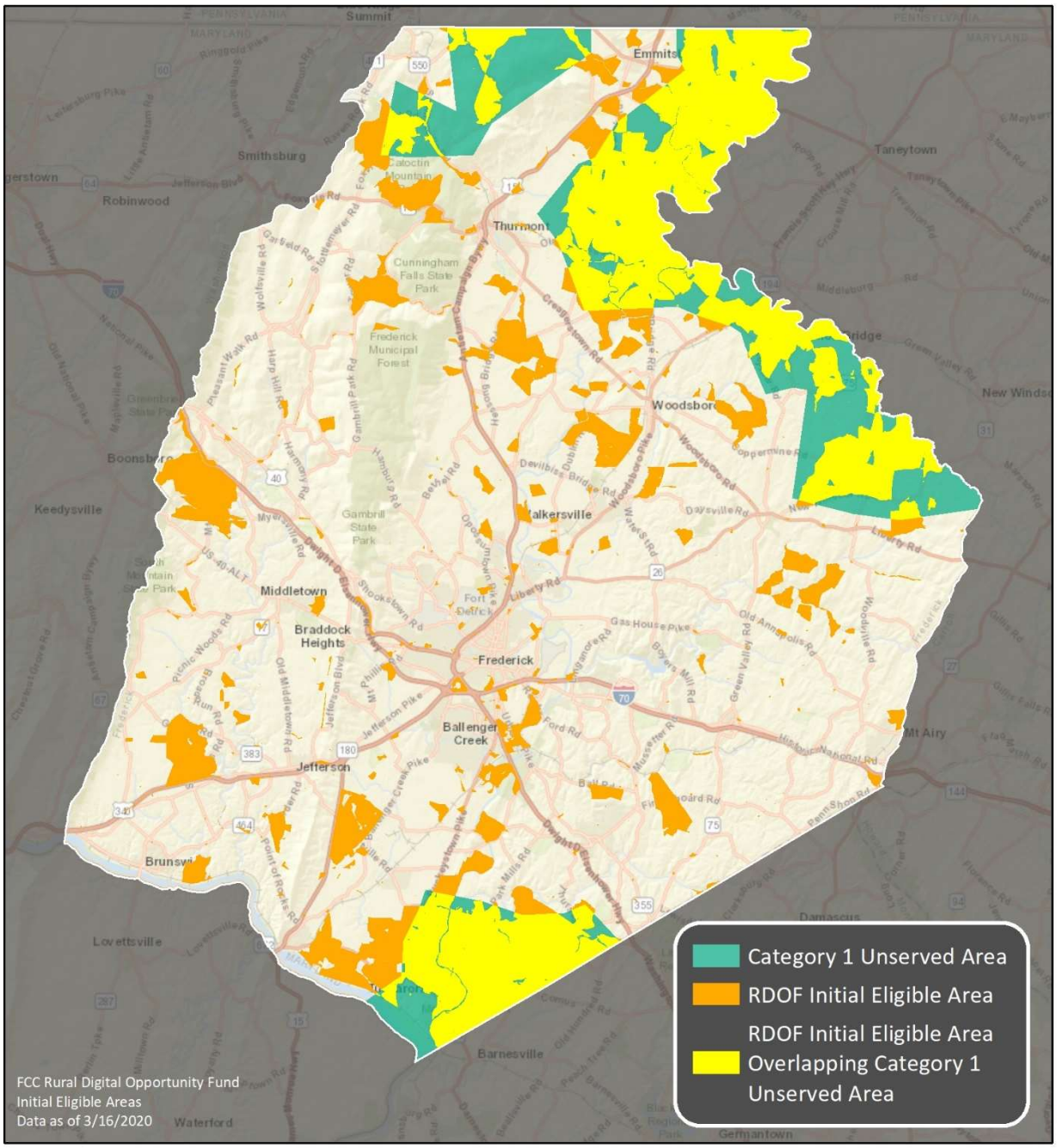
[43] "Connect America Fund Auction to Expand Broadband to Over 700,000 Rural Homes and Businesses," FCC, August 28, 2018, https://docs.fcc.gov/public/attachments/DOC-353840A1.pdf (accessed November 2019).
[44] Joseph Gillan, "Lessons from the CAF II Auction and the Implications for Rural Broadband Deployment and the IP Transition," *National Regulatory Research Institute,* https://pubs.naruc.org/pub/9F958420-E885-F843-1AEC-4D290DC9A28E (accessed November 2019).

billion will be distributed in two phases. The first phase, which relies on highly misleading Form 477 self-reported coverage areas, will consist of up to $16 billion, while the remaining Phase I budget, along with $4.4 billion, will be awarded for Phase II of the auction. The Phase I auction is scheduled to begin on October 27, 2020, and "will target over six million homes and businesses in census blocks that are entirely unserved by voice and broadband with download speeds of at least 25 Mbps."[45] The FCC believes that by the time Phase II starts, it will be able to rely on more accurate maps of unserved areas, which will include areas that the FCC currently denote as partially served as well as locations not funded in Phase I. The FCC has not so far commented on what will happen to areas currently marked as served that could be found to be unserved if more accurate maps are used.

Unlike in the most recent round of ReConnect, the FCC will fund areas that lack 25/3 service—even those that have another subsidized competitor. Also, unlike the USDA or state funding programs, the Rural Digital Opportunity Fund grant does not involve a discovery and documentation process for delineating unserved areas. Instead, it relies on Form 477 data with some further restrictions as mentioned earlier. The initial maps of eligible areas were released March 17, 2020, and are illustrated in Figure 21 with an overlay of the Category 1 unserved areas to illustrate the narrower assumptions of eligibility adopted by the FCC for this round of the Rural Digital Opportunity Fund. Nevertheless, the map shows some promises for reaching a substantial number of unserved addresses in the County.

[45] "Fact Sheet – Rural Digital Opportunity Fund Information," FCC, https://www.fcc.gov/auction/904/factsheet (accessed April 1, 2020).

Figure 21: Unserved Areas and Census Block Groups Initially Eligible for Rural Digital Opportunity Fund



The FCC will be using a reverse auction mechanism almost identical to the one used in the CAF Phase II auction, though this time incumbent price-cap carriers will not have the right of first refusal.

The FCC has announced it will be awarding funds through two phases, the first focused on those areas wholly unserved by broadband at speeds of 25/3 Mbps, and the second on partially-served areas. As in the CAF Phase II auction, the FCC will use the CAM to establish the maximum subsidy available for each eligible area, and bidders compete for available subsidies with preference given to those bidders willing to commit to offering faster speeds and lower latency service. The bidder willing to commit to providing an area with the best quality service at the lowest subsidy amount wins the available support.[46] In fact, to incentivize more sustainable approaches to broadband deployment such as fiber and cable approaches rather than fixed wireless and satellite, FCC changes the weights assigned to the different proposed technologies further in the direction of higher speeds and lower latency.[47]

The biggest change the FCC adopted was raising the service availability threshold to 25/3 Mbps, making even those areas where a provider received CAF funding for 10/1 Mbps service potentially eligible for support. The Commission is also considering a number of other minor adjustments, such as changing the minimum bidding areas to census block groups, census tracts, or counties.

While the FCC had considered adding a subscribership benchmark[48] to the awardee to ensure that a high percentage of unserved addresses in the area would receive service, it ultimately decided not to include such a requirement as it concluded it would discourage bidders and change the program from a deployment to an adoption program. Should the County partner with a bidder or support a bidder directly or indirectly, it should therefore consider agreeing on targeted benchmarks of adoption as well.

The FCC did adopt a deployment benchmark so 40 percent of the targeted buildout need to be completed by year 3. If this benchmark is not met, the awardee will need to notify the FCC and will have six months to come into compliance to avoid a default.

In addition, the FCC has made some additional changes from CAF II to incentivize bidders further to build in unserved areas: The threshold for allowing CAM subsidies for unserved areas have been lowered from $52.50 to $40 to reflect that areas that many areas that were thought to have sufficient ROI not to require federal subsidies to attract deployment have remained unserved.

[46] Federal Communication Commission, "Rural Digital Opportunity Fund, Connect America Fund," 84 FR 43543, August 21, 2019, https://www.federalregister.gov/documents/2019/08/21/2019-17783/rural-digital-opportunity-fund-connect-america-fund (accessed November 2019).
[47] Federal Communication Commission, "Rural Digital Opportunity Fund, Connect America Fund - A Rule by the Federal Communications Commission on 03/10/2020". https://www.federalregister.gov/documents/2020/03/10/2020-03135/rural-digital-opportunity-fund-connect-america-fund (accessed March 2020).
[48] Federal Communication Commission, "Rural Digital Opportunity Fund, Connect America Fund."

And to reflect the particular difficulties for deployment on tribal lands, the threshold was lowered to $30.[49]

We note, too, that a Rural Digital Opportunity Fund application would not exclude applying to other federal and state programs. The County could have a partner applying for funding from multiple sources. However, the Rural Digital Opportunity Fund does exclude previously funded and executed projects that include the same areas, so the timing of executing state funding awards for designated areas, and delineating those areas to which the County and its partner(s) apply for the Rural Digital Opportunity Fund, need to be aligned if the County and its partner want to leverage multiple funding sources to maximize support and the areas targeted.

6.5 USDA's Community Connect Program

Community Connect is another program to which the County could apply with a partner. The USDA administers this modestly sized grant program for local and tribal governments; it targets broadband deployment to unserved (defined as speeds less than 10 Mbps download and 1 Mbps upload), low-income rural communities with fewer than 20,000 residents in a contiguous PFSA (*and* not adjacent to cities with more than 50,000 residents). To prepare the most competitive Community Connect grant application possible, we would recommend the County target the lowest-income portions of its unserved areas. The eligible areas for funding are therefore identical to the PFSAs developed for the ReConnect grant, but with an additional low-income requirement.

Grantees must ultimately offer service at the broadband grant speed (defined as 25 Mbps download, 3 Mbps upload) to *all* households and community institutions in the PFSA, with free service for at least two years to a community center.

The application process is rigorous and competitive (i.e., only about 10 percent of applicants receive an award) and once awarded, program requirements can be demanding (e.g., requiring last-mile service be available for all households in the service area). The program has been funded consistently since it was introduced in 2002 and represents an important opportunity for qualifying communities.

Eligible applicants include local or state units of government, incorporated organizations, Indian tribes or tribal organizations, cooperatives, private corporations, and limited-liability companies organized on a for-profit or not-for-profit basis. Individuals or partnerships are not eligible. Any public or private applicant must have the legal capacity and authority to own and operate the proposed broadband facilities, to enter into contracts, and to otherwise comply with applicable

[49] Ibid.

federal statutes and regulations. Thus, awards cannot be granted to a local government entity that does not want to own or operate the broadband service.

Once awarded, projects must offer last-mile service at the broadband grant speeds (25 Mbps download and 3 Mbps upload) to *all* businesses, residents, and community facilities in the PFSA, with free service provided to all critical facilities,[50] and at least one community center (with weekend hours and two to 10 public computer access points) for at least two years from the grant award. Grants can be used to offset the cost of providing such service and to lease spectrum, towers, and buildings as part of the project design.[51] The lesser of 10 percent of the grant or $150,000 can be used to construct, acquire, or expand an existing community center.[52]

6.6 COVID-19 Funding Opportunities through Department of Commerce

The Department of Commerce's Economic Development Administration (EDA) oversees the Economic Development Assistance program, which has delivered funds to distressed communities for many years. Public broadband projects in economically distressed communities are eligible for funding under the Public Works and Economic Adjustment Assistance (PWEAA) programs—which do not require that an area is unserved, but do require that jobs be created or saved as a direct result of the proposed project.

The Coronavirus Aid, Relief, and Economic Security (CARES) Act added $1.5 billion to the EDA's existing program, representing a significant opportunity, both because of the size of the allocation and its breadth of eligibility relative to the original EDA grant program.[53] The grants were made available to local and state governments, non-profits, and other non-commercial entities that have a compelling case for using infrastructure projects (including broadband initiatives) to ameliorate the economic effects of the Covid-19 crisis. Broadband projects—including in non-rural areas—that will help address coronavirus challenges are eligible so long as they will strengthen economic resilience, diversify the economy and workforce, or support recovery.

As of the date of this writing, this CARES Act-funded opportunity is still technically open, but an application process can be lengthy and the special one-time funding will likely be expended in the near future. Notably, the CARES Act-funded EDA grants require a reduced match (20 percent

[50] Critical community facilities include public schools, public libraries, public medical clinics, public hospitals, community colleges, public universities, law enforcement, and fire and ambulance stations.
[51] Leasing costs can only be covered for three years.
[52] Note that additional funds can be used to provide the computer access points and their connection to the network. Applicants may use their own resources to cover costs exceeding this limit. The program historically required provision of at least 10 computer access points in a public community center; however, now requires only two such access points—with a *maximum* of 10 computers.
[53] More detailed guidance regarding this program is available at https://www.ctcnet.us/blog/1-5-billion-in-new-grant-funding-available-from-economic-development-administration-for-broadband-other-projects/.

of the project budget rather than 50 percent) and take a less stringent approach to the normally required Comprehensive Economic Development Strategy (CEDS). While project concepts need to be developed and resources mobilized to work with an EDA representative on an application, it is a welcome opportunity for broadband related funding that is not tied to strict eligibility criteria of unserved areas but can target underserved areas from a community or business service offerings perspective as well. The EDA program is one of the vehicles congressional proposals for CARES and stimulus funding have identified for funds distribution for such one-time disaster or stimulus-related funding.

EDA also has its original $587 million grant program[54] The process is more involved and requires an EDA-compliant Comprehensive Economic Development Strategy (CEDS) that informs or justifies a proposed project. The match requirement, however, is a steeper 50%. EDA's materials on its Public Works program (which is what a broadband project would target) explicitly mention broadband,[55] but it does not appear that broadband funding has been a significant part of the portfolio. Over a period of a decade (2007–2017), the EDA's annual reports included only eight references to relevant projects.[56]

While broadband funding to date through the EDA appears to be modest, both construction and technical assistance are clearly eligible. Moreover, applicants can apply non-federal funds toward the cost-share, which allows them to leverage available resources. Additionally, the program does not require proof of lack of service or poor service. Instead, a proposed project must demonstrate that it will positively affect the economic prospects of the area; generally, in the form of addition of or saving of jobs. A CEDS that highlights a need for better broadband will be an essential first requirement. Given this, we recommend the County consider this opportunity. to the extent that there are specific geographic areas of economic distress in the County and a relevant CEDS that includes the areas in question.

For both the original and CARES act related funds, the PWEAA Notice of Funding Opportunity (NOFO) emphasizes the importance of consulting with the appropriate regional EDA contacts.[57] Regional staff is available to review project proposals, assess proposed cost shares, and preview all application materials. Though optional, we believe that such consultation would ultimately be beneficial if the County were to consider applying.[58]

[54] See https://www.grants.gov/view-opportunity.html?oppId=302953 (accessed November 2019).
[55] "Broadband Funding Guide," U.S. Department of Commerce EDA, December 12, 2018, https://broadbandusa.ntia.doc.gov/sites/default/files/funding_eda_01_0.pdf (accessed December 2019).
[56] EDA annual reports available online at: https://www.eda.gov/annual-reports/ (accessed November 2019).
[57] "Notice of Funding Opportunity – FY 2020 EDA Public Works and Economic Adjustment Assistance Programs," https://www.grants.gov/web/grants/view-opportunity.html?oppId=321695 (accessed December 2019).
[58] EDA regional contacts available online at: https://www.eda.gov/contact/ (accessed November 2019).